HOW TECHNOLOGY AFFECTS TEACHING

by

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October 1987

This document was prepared under a contract with the Office of Technology Assessment, Congress of the United States, for the assessment, *Power On: New Tools for Teaching and Learning.* The conclusions are those of the authors. The document does not necessarily reflect the analytical findings of OTA, the Advisory Panel, or the Technology Assessment Board.

J952-37

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October 1987

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Office of Technology Assessment
Congress of the United States
Washington, D.C.

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ACKNOWLEDGEMENTS

This study would not have been possible without the generous assistance of the many school people who took treasured summer vacation time to share their ideas and answer our questions. They came from ten sites all across the United States: Casper, Wyoming, Contoocook Valley, New Hampshire, Fairfax County, Virginia, Houston, Texas, Lexington, Massachusetts, Mercer Island, Washington, Minneapolis, Minnesota, New Orleans, Louisiana, San Diego, California, and Washington, D.C. We thank them. We also want to express our appreciation to the twenty teachers from the Boston area who participated in the two focus groups that were held at the beginning of the study. They helped us sharpen the focus of the study and be more thoughtful in the questions we were asking.

In particular, we would like to thank our colleagues in the ten sites who identified and located the teachers we interviewed -- a remarkable achievement given that teachers were out of school for the summer.

We also appreciate the assistance of our Advisory Board: Elizabeth Bjork, Patricia Butler, Magdalene Lampert, Beth Lowd, Karen Sheingold, Charles Thompson, and Daniel H. Watt. Their wise and timely recommendations strengthened the design and analysis of findings.

Finally, we thank Angela Daskalos and Gerry Sills for grace, speed, and accuracy in the face of temperamental technology and persnickety writers.

EXECUTIVE SUMMARY

The principal objective of this study is to assess how teachers are affected by the challenges and opportunities provided by computer technology. The study is based on in-depth interviews with 76 teachers from 10 sites around the country. The respondents at each site and as a group represented a diversity along a number of variables: subject area, grade level, function and role, type and extent of computer use, and gender. They were asked:

- how and why teachers use computers;
- what training and support have been available to teachers;
- what effect computers have on teachers and students;
- what influence teachers have and might have on technology and on how it is used.

Interview data were analyzed to identify themes and to construct seven composite profiles of teachers that articulated those themes. The composite teacher profiles represent a range of users and non-users of technology, a variety of roles at the elementary and secondary school levels, and different perspectives on the educational uses of computers. The profiles portray the following points of view:

- Ambivalence about Technology
- Looking Forward to Teaching with Technology
- Using Computers in an Elementary Classroom
- Using Computers in Special Education
- Teaching Computer Science and Computer Literacy
- Integrating Computers into the Secondary Mathematics Curriculum
- Supporting and Training Teachers

The findings drawn from all the interviews address: (1) influences on teachers' decisions about teaching with technology -- teachers' beliefs, external mandates and opportunities, and access to resources and support; (2) effects of computers on teaching style, classroom management, and teachers' roles; and (3) resources and support teachers want -- hardware and software, effective training and ongoing assistance, visions of teaching with technology, layers of administrative and technical support, and greater influence on educational technology policy, applications, and use.

The findings suggest that policy efforts focus on the computer as an instructional tool, and that an integrated system of resources is necessary to support such use. Teachers and schools need information about possible approaches for integrating technology into instruction and for supporting teachers in these efforts. Assessment and documentation on the

implementation process, student learning, and other effects are essential.

The report concludes that it is premature to identify models and exemplary programs and that efforts should be devoted to experimentation and dissemination, taking full advantage of all available public and private resources.

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INTRODUCTION

This study provides an opportunity for teachers to speak to policy makers about their experiences with educational technology. It was designed to clarify how teachers use computers, what has influenced their decisions, the effects that new technologies have had in their classrooms, how they would like to use computers, and the resources and support they seek. By talking directly with teachers, we hoped to bring their views to bear on the policy decisions that will affect teachers as they continue to integrate new technologies into their classrooms.

COMPUTERS CAN SERVE A RANGE OF EDUCATIONAL PURPOSES

Computers can be programmed to serve an almost unlimited range of purposes; thus they have been likened to a Rorschach card (Amaral, 1983), onto which educators can project their own goals and their assumptions about the process of teaching and learning. Equipped with appropriate software, computers can be used in a variety of approaches ranging from carefully directed instruction to completely open-ended exploration. Some forms of computer-assisted instruction, for example, cast the computer in the role of a teacher who tutors students and assigns problems that allow students to rehearse their knowledge and practice their skills. Such approaches reflect a view of learning as a process of memorizing known facts and algorithms. At the other extreme, some kinds of educational software are designed as "electronic sandboxes" in which students are expected to discover

knowledge through their independent explorations. Such software assumes that learning is mostly a process of invention. Both of these uses of educational technology tend to engage students directly, without requiring direct involvement of the classroom teacher.

Still a third kind of software can empower both teachers and learners. In this category one might include generic "tool software" such as word processors, databases, and spreadsheets, as well as certain kinds of subject-specific software packages that represent and manipulate information in ways that are not possible with the traditional, static media of books and chalkboards. Such software does not make the computer a substitute for the teacher, but rather makes it into a powerful tool that can enrich or increase the efficiency of teachers' and students' efforts.

Given the range of possible uses of computers, we expected to hear a wide variety of stories about the impacts of computers and the kinds of training and support that teachers want. Our expectations were further shaped by prior research on the implementation of educational innovations in general and the introduction of computer-related technologies in particular.

PRIOR RESEARCH ON THE IMPLEMENTATION OF NEW EDUCATIONAL TECHNOLOGIES

During the past two decades, research on educational innovations has increasingly focused on the teacher as the central character in implementing new instructional practices (Berman, 1981; Crandall et al., 1982; House, 1979; Huberman et al., 1983). Whereas earlier studies of educational change focused on the dissemination of knowledge about exemplary practices (Havelock, 1969), more recent work has focused attention on the process of carrying out innovations. It has revealed that teachers adapt innovations in light of their own goals, their accustomed practices, the culture and organizational structure of their school context, and their interpretations of the information they receive about new approaches (Berman & McLaughlin, 1974 and 1977; Doyle & Ponder, 1977; Farrar et al., 1981; Sarason, 1971). Researchers who have looked particularly at computer-based interventions stress that teachers' needs must be taken into account (Kimmel, Kerr, & O'Shea, 1986), preferably including them as partners in research and development designed to implement technology in classrooms (Sheingold, Martin, & Endreweit, 1985).

Teachers alone, however, cannot initiate and sustain innovation without training, resources, and support. Innovation is greatly affected by the amount and quality of assistance (Huberman & Miles, 1984). This is particularly true for

computer-based innovations. Teachers need training in content, technology, and classroom management (Cline et al., 1986; Sheingold, Martin, & Endreweit, 1985; Watt & Watt, 1986) that shows them how to connect the innovation to their regular courses and classes (Doyle & Ponder, 1977; Mohlman, Coldarci, & Gage, 1982). When an innovation requires teachers to rethink their subject matter as is often the case when using computers, they benefit from the assistance of an "advisor" or "helping teacher" (Zigarmi, 1978; Rauh, 1978; McDonald & Naso, 1986). This person should not merely advise, but actually alleviate the burdens of innovation through preparing materials and teaching or assisting in the classroom. Another form of sustained assistance that teachers find particularly valuable is consultation with colleagues who are attempting to adapt similar innovations in their own classrooms (Cline et al., 1986; Kimmel, Kerr, & O'Shea, 1986; Sheingold, Martin, & Endreweit, 1985; Stalling, Needels, & Stayrook, 1978; Watt & Watt, 1986; Wiske, 1986).

Several research projects have looked closely at the resources teachers need in order to incorporate computers into their classrooms. These include the Educational Technology Center's laboratory sites project which studied the process of implementing research-based innovations in science, mathematics, and programming in several secondary school sites; studies of the IBM Model Schools Program (Cline et al., 1986; Stecher & Solorzano, 1987; Watt & Watt, 1986); studies of the Voyage of the Mimi, an interactive multi-media curriculum (Martin, 1987); and

research on the uses of Logo in classrooms (Hawkins, 1985; Hawkins & Sheingold, 1986). All of them have pointed out the complex logistics associated with acquiring access to necessary hardware, software, and related equipment and materials.

Finally, prior research has shown that teachers need support within their school settings in order to undertake innovations. Administrators including principals, department heads, and superintendents (Farrar, 1987; Loucks et al., 1982; Wiske, 1986) play a key role in providing leadership and distributing incentives from tangible rewards to moral support.

ORGANIZATION OF THIS REPORT

This report reflects the organization and chronology of the study. The methodology section describes the selection of respondents, the design of the interview questionnaire (based on the literature summarized above), and the process of collecting and analyzing interview data. The data are synthesized and reported in a series of profiles of teachers, each of whom represents a subset of the teachers we interviewed. These profiles are:

- Nancy Rudman:
  Ambivalence about Technology
- Abby Miller:
  Looking Forward to Teaching with Computers
- Laurie Adler:
  Using Computers in an Elementary Classroom
- Chris Johnson:
  Using Computers in Special Education

- Carolyn Hemenway:
  Teaching Computer Science and Computer Literacy

- Marilyn Gordon:
  Integrating Computers into the Secondary Math Curriculum

- Alan White:
  Training and Supporting Teachers

The discussion section complements the portraits by summarizing patterns that emerged across the entire set of respondents and discussing them in light of related research. Finally, we discuss the policy considerations implied by our findings.

METHODOLOGY

OVERVIEW

Teachers from ten diverse sites across the nation, reflecting a wide range of backgrounds and experiences, voiced their opinions regarding the use of computers in education. We collected data through in-depth telephone interviews. Among the topics investigated were computer use, training and support, effect of computers on teachers and students, and teachers' influence on technology. Based on a comprehensive review of the data, we constructed composite teacher profiles.

The methodology used in this study is presented in four sections:

- Sample: a detailed description of the sample focusing on demographic information.
- Interview Questionnaire: a discussion of the interview questionnaire, including the rationale for selecting this format and the design of the questionnaire.
- Data Collection: a review of the steps involved in data collection.
- Data Analysis: a discussion of data synthesis, with attention to identifying themes and constructing composite teacher profiles.

SAMPLE

The selection of the sample was guided by several factors. We included in the sample teachers from many subject areas and grade levels to ensure that the data would reflect the full spectrum of teaching disciplines and educational computer uses. Computer users and non-users were represented, and we interviewed

approximately equal numbers of women and men. Regional diversity afforded us results that were not unduly influenced by any one geographic setting.

In early summer of 1987, we selected ten regionally-diverse school districts, including urban, suburban and rural sites across the country. The following sites were chosen: Casper, Wyoming; Contoocook Valley, New Hampshire; Fairfax County, Virginia; Houston, Texas; Lexington, Massachusetts; Mercer Island, Washington; Minneapolis, Minnesota; New Orleans, Louisiana; San Diego, California; and Washington, D.C. Next, using informal networks, we obtained the names of potential respondents at each site. In selecting the sample, we attempted to balance each teachers' position, extent and type of computer use, and gender. From this pool, we contacted teachers by telephone, asking if they would participate in a study investigating the effect of technology on teachers. We explained that participation would involve being interviewed on the phone for approximately one hour, and assured the teachers that, although the findings would be shared, respondents would not be identified by name. Most teachers who were contacted agreed to participate.

Seventy-six teachers, all from public school systems, participated in the telephone interviews. The majority (70%) of respondents were full-time classroom teachers; the others held different positions, including those of teacher trainer and computer coordinator. The teachers were distributed fairly

evenly along the K-12 spectrum: 34% taught at the elementary level (grades K-6), 24% taught at the junior high level (grades 7-8), 33% taught at the high school level (grades 9-12), and 9% taught at more than one school level. Forty-nine percent of the respondents taught only one subject: math (20%), science (8%), social studies (6%), computer science (4%), English (4%), special education (4%), and foreign languages (3%); the others taught several subjects or coordinated specialized resources. School populations ranged in size from 82 to 2400 students (mean = 955; median = 820).

Most respondents had considerable teaching experience; the range extended from 1 to 33 years (mean = 16; median = 18). On the whole, teachers in the sample were well-educated; 45% had received an advanced university degree. Slightly more than half (59%) of the teachers were women. Approximately half (47%) of the respondents had one or more computers in their classrooms for the entire year, while 5% had a computer in their classrooms only occasionally. Thirty-eight percent of the respondents described themselves as extensive computer users, 20% as moderate users, 18% as occasional users, and 24% as non-users. The great majority (92%) had received either formal or informal computer-related training.

INTERVIEW QUESTIONNAIRE

We chose a telephone-interview format for data collection. This approach offered several advantages. First, the one-on-one

approach enabled the interviewer to probe individual responses. Second, telephone interviews allowed us to collect data from teachers across the country within a short time-period at minimal cost.

With the format established, the research team developed a preliminary version of the questionnaire. The questionnaire, guided by our review of the literature and our own prior research, focused on four topics: (1) computer use, (2) training and support, (3) effect of computers on teachers and students, and (4) teachers' influence on technology.

The team then conducted two focus group sessions with teachers in metropolitan Boston. One session involved computer "users" (11 teachers), and the other involved "non-users" (9 teachers). During these informal discussions, lasting approximately three hours, we explored research themes and tested questionnaire items. The discussions, structured around the questionnaire items, served to delineate the range of responses we could expect during the telephone interviews. Based on the findings from these sessions, we refined the questionnaire (see Appendix for the questionnaire).

DATA COLLECTION

Six researchers conducted the telephone interviews during a four-week period in July and August 1987. Each interview was audio-taped (with the respondent's permission). We first asked general questions to investigate each of the four major topics

(computer use, training and support, effect of computers on teachers and students, and teachers' influence on technology). We used follow-up probes to elicit detailed accounts. All questions were phrased to avoid leading the answers in a specific direction. In addition, we asked factual questions regarding demographic information.

At the conclusion of each interview, the researcher wrote extensive notes for each of the four areas under investigation, and transcribed some vivid or insightful remarks to illuminate specific viewpoints. Participants received a small honorarium for taking part in the study.

DATA ANALYSIS

The goal of data analysis was two-fold: to identify recurring themes that emerged in the interviews and to construct composite teacher profiles that articulated these themes. The research team sifted through the notes from the interviews by questionnaire category; that is, we examined what teachers in the study had to say about type and extent of use, training and support, the effect of computers on their professional lives, and the role teachers played in decisions affecting computer use in their school or district. We identified primary themes in each category, and re-examined the data to confirm or revise the team's preliminary assessment. Each set of notes was reviewed to confirm patterns, distribution, and frequency of response. We then organized our findings into a series of composite teacher

profiles, each giving life to one or more major themes. We decided to vary two parameters in each profile: extent of computer use and teacher function. We chose the first criterion, extent of use, because we wanted to tell the stories of teachers who made extensive use of computers in their classrooms, as well as the stories of non-users. We chose the second criterion, teacher function, because we realized that an effective way to tell part of the story of computers' effect on teachers was to describe real teachers doing real jobs -- such as teaching elementary classrooms, special education classrooms, or high school English classrooms.

Each profile is based on 3-12 interviews. Each follows a similar organization: introduction, computer use, training and support, effects of computers on teachers and students, and teachers' influence on technology. We reviewed the profiles for accuracy, and prepared a discussion section to help the reader interpret the profiles in the context of the total sample and in light of other research.

TEACHER PROFILES

The composite teacher profiles articulate teachers' opinions regarding the use of computers in education. Each profile depicts a teacher in a distinct school setting. This specific context creates an opportunity for voicing a representative point of view within the educational community. It should be emphasized that each teacher profile is a composite based on elements taken directly from the interviews. Therefore the profiles maintain the flavor of the actual responses while ensuring the confidentiality of the participants. Note that the names attached to each profile are fictitious.

The following profiles present multiple perspectives on educational uses of computers:

- Nancy Rudman:
  Ambivalence about Technology
- Abby Miller:
  Looking Forward to Teaching with Computers
- Laurie Adler:
  Using Computers in an Elementary Classroom
- Chris Johnson:
  Using Computers in Special Education
- Carolyn Hemenway:
  Teaching Computer Science and Computer Literacy
- Marilyn Gordon:
  Integrating Computers into the Secondary Math Curriculum
- Alan White:
  Training and Supporting Teachers

NANCY RUDMAN:

AMBIVALENCE ABOUT TECHNOLOGY

`Nancy Rudman´ typifies the chairperson of a suburban high school English department who is ambivalent about her students´ use of computers at school and at home. Although she believes every student should learn to use computers because "they are the writing tool of the future," she sees problems with word processing. "Kids ... think that because it looks neat, it´s done.... They haven´t learned how to write and rewrite." She supports the state-mandated computer literacy requirement but is concerned that such mandates may lead to academic mediocrity (her district made room for the requirement by dropping a semester of English and history). Though there are no computers in her classroom, her experience with word processing has changed her teaching. She now demands more revisions from her students "without feeling too guilty ... Because I know how easy it is for them to redo it."

INTRODUCTION

Nancy Rudman is the chairperson of the English Department at a high school of 1100 students located in an affluent suburb in the Northeast. A teacher with 20 years of classroom experience, Nancy has a B.A. in English and has taken an additional 180 hours of courses towards a graduate degree.

Although she doesn´t use computers in her classes, a third to a half of her students use computers at home for word processing, a practice she encourages. Her school has a computer lab with about 30 Commodores and an assortment of other machines that are used for a variety of purposes, ranging from word processing to programming and mathematical problem solving. Recently the Business Department bought some IBM PCs and the word processing program Word with which more and more students are

becoming familiar. Students are allowed to bring their floppy disks from home and do some of their writing in the computer lab.

COMPUTER USE

Nancy doesn't use computers in her teaching because the computer lab is reserved primarily for math and science classes and for individual student use. A few years ago, there were plans for the English Department to get a computer resource center of its own for word processing: teachers would bring their English classes to the resource center and each student would come with his or her own disk to work on. But the funding for the resource center fell through; the English department even lost its secretary.

The district's money problems stem from two circumstances: declining enrollments and a statewide tax limitation measure recently passed by the legislature. The law imposes a cap on the amount of money a district can raise, so that even if an affluent district such as Nancy's wanted to raise more money for education, it would be forbidden to do so. One result of budget cuts is that class sizes have gone up.

Nancy believes every student should learn to use a computer because "they are the writing tool of the future." In the six months she has used a word processor -- she and her husband bought an IBM clone for home use -- she has "gone from hating every moment of it and taking eight hours to do a half-hour typing job, to getting to the point where I can now write first

drafts and I can really do things more easily on the word processor than I could on the typewriter." Nancy uses her microcomputer to write letters of recommendation for her students, a common use among the high school teachers in our sample. With 25-30 seniors in her English class, each applying to 2-3 colleges, she has to write some 70 to 80 letters of recommendation every year, a chore that used to take an enormous amount of her time. "The machine made life possible," she says with relief.

Nancy supports the new state policy that requires students to take a one-semester computer course. She believes the policy will produce children who are comfortable with computers. "As an old dog trying to learn to use this thing," she regrets that she didn't start years ago when microcomputers first came out.

TRAINING AND SUPPORT

Nancy took a week-long district, in-service workshop on Word for which she was reimbursed at the usual workshop rate of $6 an hour. She appreciated what she regarded as a token payment, because it signalled that the district valued her efforts to learn word processing. What's more, the workshop helped her get over her "high-tech anxiety." She describes herself as someone who has always resisted and hated computers, "a nineteenth-century person kicking and screaming my way into the twentieth-century." "Having that workshop at school was very good. And having the resource there of a teacher who really knows her

machine is good, because that gave me lots of confidence. And I feel better teaching."

Nancy had high praise for the workshop she attended, calling it "the most useful use of time I've ever had after school." She contrasted it with other workshops she's taken: "Most workshops are game time. Let's go in and get warm and fuzzy... and learn some cute new gimmicky words to deal with styles of learning and personality. And some guy comes in and sells himself ... usually under the title of management consultant.... Well, it's a warm fuzzy for three hours or four hours [but] it's nothing we can really use.... But having a real workshop on learning to use Word was wonderful."

When she started using the computer, Nancy felt stupid and frustrated, but she found "a lot of camaraderie and a sharing of ignorance," and a sense of "struggling together" among her colleagues. She quickly got over her embarrassment about being "wrong in front of your colleagues," and the feeling that "if you're going to be wrong, you want to be wrong alone."

An important ingredient in Nancy's sense of competence and mastery of her word processor was having a computer at home. She had time to get over her initial anxiety, to try things without other people watching, to practice, and to explore. Having experienced the benefits of a readily accessible word processor, she wants the school to make more computers and more workshops available for teachers, "to get them to know the machines, to know what's available, so they can get the kids to do it."

Nancy's school has three part-time computer resource people: one of the three, a woman in the business department who is the support person for "Word," has been particularly helpful to Nancy, coming to her rescue when she first started, and always being available to answer both large and small technical questions.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

The computer has had a profound effect on her teaching, Nancy says, because it allows her to demand that students rewrite their papers "without feeling too guilty. I get to worrying a little bit that I'm just a terrible mean lady. I make my kids rewrite until they bring it up to a good standard. And that will be two or three times for me. I'll just butcher papers. Some are just red. And I have no compunction doing it now. I really feel happy I can just read these papers and circle them. Because I know how easy it is for them to redo it."

But Nancy also sees problems with word processing. Many of her students "depend upon the machine for their first drafting, and they turn it in and they think that's it. And what they really haven't done is ... edit. What I notice is a lot of repetitions of phrases, wordiness that isn't necessary because when you're writing by hand or you're working from a printed out copy, you can go back and see what you've done, see what your errors are and ... pencil in the margin and look up words. Kids think that because it looks neat it's done. They haven't learned

how to write and rewrite. And I think part of that just comes with the word processor. As long as you rely upon the visual -- the screen in front of you, you're never going to be able to see the whole document, really remember it and see it. That is just what is inherently wrong with a word processor."

Nancy wishes her students would take advantage of the new technology "to free associate, put things down, then print it out and then work with that printed out form, penciling in, looking at it, reading, marking what you want to then do, and then go back on the machine and edit and move things around." But she worries that most people don't know how to write with computers. In part, she blames people's misuse of computers on their inability to plan and to organize their thinking. People "try and open up windows, try moving everything around before they have really seen the whole thing. They don't think enough on their own, and they don't print [drafts] out often enough."

Nancy finds that students who write out their papers in long hand are much more conscious of their words, "of what they have written, their thinking." In contrast, students who work on the word processor, particularly when they start, "are just letting the machine dominate them.... It looks good but nothing's there.... I would say that 75 to 80 percent of the typed papers of my non-honor students are better than the machine papers. It is strictly related to thinking."

Nancy distinguishes between average students, who are easily seduced by the slickness of the technology and honors students

who are familiar with computers and have learned to use them more effectively. Even honors students, however, can "get a little slick and superficial on the machines. It shows up as lack of word originality, or sentence originality, repetition of ideas; they don't quite pull them together, they don't quite pencil things out enough."

The difference between honors students and non-honors students, according to Nancy, is that honors students have had more experience with word processing and are better at thinking through a writing assignment. Average students, in her view, "don't think enough," don't do enough planning and organizing, and don't take the time to look at what they've written in its entirety. They haven't learned to print out a draft, read it, correct it, and then enter the changes into the computer. By contrast, most honor students, according to Nancy, are able to see things as a whole before they sit down to write. Many of Nancy's honors students work from a hand-written first draft; a few prefer to compose at the machine.

Like most of her honors students, Nancy writes a first draft in long hand, reads it over, revises it, uses arrows to move text around, and continues to compose and change the text even as she sits down at the keyboard. She is able to do this, she says, "because I have seen something as a whole. And I think that is the step that seems to be missing with kids. They don't really know how to revise as they're going.... And I think the only way you can teach this is to make them do it. Make them show you

their first draft with their red marks on it. And then have them show you the final copy."

Despite her best efforts, many of Nancy's students, even after marking up their first draft and showing it to her, will return to the machine and simply re-copy their original draft. Nancy thinks this happens because the computer makes things too easy. "Students go flash, flash, flash, flash, and they don't bother. They don't look at the sheet that they have; they go back and look at their monitor. That's the real problem. Until monitors display a whole page, you're never going to be able to get good composing ability."

But mostly Nancy blames teachers. Until teachers demand more rewriting they're not going to see any improvement, she argues. "Having students turn things in that are neat and readable has been a godsend," Nancy says. But too many teachers are seduced by the neatness of students' papers. Nancy sees this as part of "the universal problem of teaching": teachers not demanding enough work from their students. Studies show, she says, that the more the teacher demands of the student, the more the student produces. "It's your tough teachers who are the ones you learn from. And so, to translate that down into computer use I think it's lack of demand from the teachers that these things be used properly."

Some of Nancy's colleagues have a different set of concerns about teaching with computers. Robert Feinbloom, a teacher of French and Spanish in Nancy's high school, doesn't use computers

in his teaching because most of the software he's found for foreign language instruction is of the drill and practice variety, intended for vocabulary reinforcement. Robert doesn't like the fact that "a kid can just push a button and if he gets the wrong answer there is no way for me to know whether he has the wrong answer or not, unless you happen to be standing right behind him. If he gets a wrong answer the computer says 'no, try again,' so he pushes another button. There is no way for me to know if a kid is guessing ninety percent of the time, whether he is just guessing blindly. I have no follow-up whether the kid is learning or not.... There is nothing that feeds back to the teacher how each kid is doing." Robert prefers to conduct daily verbal conjugation and vocabulary drills which allow him to check a whole classroom of students in five minutes.

Robert also complains about the excessive time involved in typing, about software that is geared primarily to vocabulary, and about the computer's inability to show how people communicate -- their gestures and facial expressions, how close people stand to each other when they talk, the intonation they use. He finds videotapes of native speakers to be a much more effective teaching tool.

Martha Daniels is a social studies teacher in a middle school in Nancy's district who worries that students will come to rely too heavily on computers, and that this will present problems for students' future learning. "If you don't have a computer and the appropriate diskette in hand, you're not going

to be able to go back to the information that slipped your mind," Martha says. "Learning on the computer is much easier learning, but it's not as good for retention," she adds. "If they are going to learn on the computers, and they get an exam like I get from the state, they are lost, because they are not allowed to use a calculator and not allowed to use a computer." Underlying Martha's concern seems to be an implicit view of the computer as a kind of stand-in memory, a repository of information.

Martha also associates computers with an alternative and not wholly legitimate style of teaching. "My coworker is a very casual kind of person, and she believes you can get the knowledge even if you get it just through play, but most of the times I've gone [into her class] I've seen them just playing games on computers." She perceives computer-based instruction as far too "informal" and doesn't like to see her colleague become "just a facilitator of student computer use, not an instructor."

A related concern of Martha's is that some teachers might be tempted to abdicate their instructional responsibilities to the computer or use it as a babysitter. "Unfortunately," she says, "there are not too many teachers who are very dedicated to their teaching, and many of the teachers take the computers as a pretext to do something else, leave the students alone, to get on the computer what they should be teaching in the classroom." Martha believes there are many teachers like this, and that proper use of computers in schools requires close supervision.

Rick Torn, a social studies teacher in Nancy's high school, shares Martha's view of the computer as essentially a "rote memory device." But he has other, more philosophical concerns as well. "What the hell's it for?" he asks. "I'm still wondering what a computer is supposed to do; I know it cannot think for you." He adds rhetorically: "Plato and Aristotle... were they better off or worse off because they didn't have these machines? ... I don't see that thinking, the kind of thinking you'd want for citizenship ... is enhanced by these machines."

Despite her own criticisms and the concerns of her colleagues, Nancy sees several important benefits that result from the use of computers. In the case of dyslexic children, for example, computers make it possible for them to become competent writers. "Many kids who are dyslexic ... can turn a paper in, because they have spell checks for them. I have quite a few kids -- very brilliant kids who could not possibly spell or write anything, but can do credible thinking. And once they got the machines, they went to work." She has encouraged parents of dyslexics to buy word processors for their children because she has seen impressive results: dyslexic students who score high on the math SAT but low on the verbal SAT, and who have had difficulty with handwriting or typing their papers, are now turning in good papers produced on the computer.

Nancy has also seen the computer's positive effect on low achieving students. The opportunity to use a computer, Nancy says, "seems to be what pulls them through often.... A lot of

work with them is done with computers and a lot of self-help programs are put into that. And so a lot of these kids can be reached in this way. They may not tolerate a classroom situation but they can work with a computer."

Another positive effect is that many students are suddenly in the position of helping others. "Helping with computers takes it out of the nerd category. You're no longer just a brain helping with math. This is something everyone needs help in. A lot of kids have reached out to helping other kids in ways they wouldn't have before."

TEACHERS' INFLUENCE ON TECHNOLOGY

Although Nancy supports the state computer-literacy mandate, she worries that the new computer course at the high school has weakened the curriculum. The district made room for the new requirement by dropping a semester of history and English. She suspects that the state mandate was used as an excuse to reduce the graduation requirements for English and history, something district administrators have wanted to do for a long time, she says. Nancy's concern goes beyond the effect of computers, to what she perceives as the watering down of the curriculum to accommodate the less able students -- in her district, the bottom 15 percent who do not go to college. She worries that state-mandated computer courses might exacerbate a trend she's observed for some time toward academic mediocrity.

Despite Nancy's reservations about using computers in her teaching she wants her school to acquire more computers. She worries that without more computers, a student's access to technology would depend upon the resources of each family, accentuating the split between families who have computers and those who don't. Nancy suspects that the 15 percent of the students who do poorly in school are also the ones who don't have computers at home. The lack of computers at home, she thinks, reflects a general lack of support for education in these homes. Nancy thinks that as long as teachers do not become overly dependent on technology, computers can help them do their job more effectively.

Nancy mentions two related examples as effective uses of the computer. A nearby community college requires its students to write all their papers in an introductory English course on the word processor. Students turn in each paper with their diskette and the teacher enters his comments and corrections on the student's diskette; the paper and the comments can then be printed out together. The second example involves one of Nancy's friends in California, a college professor who does all his students' corrections on the word processor. He enters all his comments into the computer, calculates the kinds of errors a student has made, and provides his students with a printout of his comments and a tally of their repeated errors.

Nancy would like to see more funding for training and computers, but not at the expense of the basic curriculum.

Making computers a requirement without providing additional funds to pay for the new courses, she argues, is forcing districts to cut back in subject areas that also deserve a prominent place in the classroom.

Decisions about computers are made "someplace in administration higher up on the hill, not by the teachers." Nancy is not satisfied with the way decisions are made: she'd like the administration to show teachers "what computers are capable of doing and let the demand and use of computers come from the ones who actually do the teaching."

ABBY MILLER:

LOOKING FORWARD TO TEACHING WITH COMPUTERS

'Abby Miller' portrays a sixth-grade teaching principal in a rural consolidated school district operating under organizational constraints. Although there is a new state-mandated computer literacy requirement at the high school level, her district currently has a moratorium on acquiring computer hardware and software. The district believes it must first develop a philosophy and comprehensive approach toward using computers. Her school will have three computers next year (a gift from a private donor), and her task will be to implement a new curriculum using computers in a school district where computer education is at a virtual standstill. As an advocate of computers, Abby believes "it will be good when the district as a whole addresses the use of computers by the children and by the staff. And then, assuming that they create some objectives, they develop a plan so that those can be fulfilled."

INTRODUCTION

Abby Miller is a sixth-grade teacher and the teaching principal of a rural consolidated school in the Northeast. The school shares a supervising principal with six other small schools in the area. The supervising principal attends most of the central district meetings with the superintendent and curriculum coordinator and is responsible for top-level decisions. Besides teaching her class, Abby is responsible for the day-to-day functioning of five classrooms in this school of ninety-five students in grades 1-6.

Abby received a B.A. degree from a midwestern university in elementary education with a minor in English. She taught third grade for four years in the Midwest and then took the position of

sixth-grade teacher in her present district. Two years ago the teaching principal retired and Abby replaced her.

Abby has started working on a M.Ed. in elementary education curriculum with a special emphasis in teaching process writing at the local university. She is a freelance writer who contributes stories on education to local newspapers.

Abby's school district takes pride in its thoughtful approach to education. Staff development is seen as ongoing and important, but the district does not rush towards fads and quick fixes. For example, it does not like to hurry children into forced development and does not yet have public kindergarten for all students.

Recently the state mandated a computer literacy requirement for all students graduating from high school, starting in 1989. This will force the district to make some decisions soon about computers. At present, the school district has decreed a moratorium on computer expenditures, pending development of a philosophy of computer use. The hope is to integrate the computer into the educational purposes of the school and insure a fair distribution of hardware. However, this caution frustrates Abby who feels that she needs some actual experience with computers before she can know what to do with them in the classroom.

Abby's school has an old TRS-80 computer which does not function -- nor has it functioned in the four years since Abby has been at the school. Abby thinks that a local businessman

contributed it some years ago when he purchased new equipment for his office. Next year the school will have three Apple IIes purchased directly for the school through a private fund in her town. A friend showed her how to use a word processor, and for the past two years she has used one for her writing at home. She is looking forward to the fall when she can introduce the computer to her students.

COMPUTER USE

Abby does not use computers in her teaching, though, because of her personal use of computers, she knew what she was missing. "I saw what it could do for my own writing -- it made all the difference as it was so easy to change and improve the text. Each time I stopped I could print out a perfect looking text!" Abby invested in a Franklin computer for her freelance writing work and felt that she had definitely become "a more productive writer, and I think a better one, too."

When a private donor in her town offered a sizeable contribution directly to the school for "whatever the staff thinks is important," Abby called the staff together to decide. The teachers considered many options such as playground equipment, school trips, and video equipment. They also considered computers.

The first-grade teacher and the fourth/fifth-grade teacher had used computers to do accounting for their husbands' home-based businesses. The second-grade teacher, although somewhat

skeptical, was intrigued by her observations of her three grandchildren using a home computer. She noticed their intense interest in the games they played and the interaction between the three while identifying playing strategies. The third-grade teacher's initial response was, "I'm forty years old. I don't need this in my life. I have enough aggravation! Are you kidding?"

After more conversation, the group of teachers agreed with the first-grade teacher's statement that computers "are going to be with us the rest of our lives, and the children are going to grow up in a world that becomes more and more computer oriented." The fourth/fifth-grade teacher added, "The more comfortable we can make them with computers, the more service we're giving them." Moreover, it seemed to the group that embarking on learning to teach with computers might turn out to be fun! Abby thought carefully about how to introduce the computers into the school. She doesn't want the computers to create divisions among the faculty, and she worries that this might happen. She ordered three Apple IIes with Imagewriter printers so that each computer system would be the same. She has heard teachers complain that it's too confusing when a school has different kinds of computer equipment.

She planned with the other teachers where to place the computers. One computer will go in the teachers' work area so that the teachers can learn to do some of their own work. She knows how important her own writing on the word processor was to

her understanding of what computers could offer a writer. She plans to find simple applications that would help teachers accomplish more effectively at least one job-related task. The application will differ for each person. She recognizes that getting teachers to use computers takes time and is content to move slowly towards teacher computer literacy. She plans to encourage teachers to take the computers home on vacations; remembering how important the long stretches of time in an unpressured setting were to her own learning. Her experience with her own Franklin taught her "that the machine is much more durable than I'd originally thought."

Abby plans to have Appleworks available for school record-keeping. She has never used the program but is confident she can learn it, a little at a time.

Abby and her colleagues are taking the long view in introducing the computers to students. They want the students to see the computer "as a useful tool" rather than as merely for games. While they want the computer to become part of each curriculum area and to be used with all students, they are faced with the prior task of creating a computer literate population and gathering more resources. Thus, the teachers decided to place the two computers in Abby's classroom for the first year.

Abby will use two software packages with her students: the Bank Street Writer word processor and the Logo computer language. First she will teach her sixth-grade students to use the Bank Street Writer for word processing. She hopes that after they

have learned to write, revise and publish their writing with the computer, they will be able to teach the rest of the students in the school. Later she plans to add Logo, a mathematical problem-solving tool which she has never seen but about which she has heard good things. Her district owns The Voyage of the Mimi which matches with the science competencies she teaches, so eventually she plans to try that as well.

Abby wants all students to have a chance to learn to use computers. She knows that two computers will not seem like a lot after they really begin to use them. But for the present she is content to think of grades one through five having just a taste of computer literacy since "all students will eventually become sixth-graders."

TRAINING AND SUPPORT

Abby has received little formal training in the use of computers. She once took a course on DEC computers through a community education program, but "there was no computer to practice on and it was about using that computer, not about teaching with the computer. It seemed pointless since I didn't have access to a computer." By contrast, Abby remembers the time a friend showed her how to use a computer for writing as a much more practical learning experience. He showed her only what she needed to know in order to do something, and when she was ready he showed her something more. "I learned what I wanted to learn. It wasn't as if he decided, the way you would in a classroom or

in-service," she recalls. Abby would like to use this model with her four colleagues next year. She wants them to know they have a friend who's available to give them individual help.

Abby would like access to a friend, too, like the high school resource teacher, Terry Skinner, who is very willing to help other teachers. Abby observes that people who are enthusiastic about computers are "usually more than willing to show you what you need to know. They enjoy acting in this support capacity." But the high school where Terry Skinner teaches is 23 miles from Abby's school, so that getting together for help presents some problems.

There is support in the district for teachers' professional development in all curriculum areas, including instructional uses of computers. "But it's not something they are pushing like the T.I.P. training (Theory Into Practice of Madeleine Hunter) or the Reality Therapy (of William Glasser) workshops. A teacher has to want it," says Abby. In this rural setting "it's taken a longer time to convince people that computers are going to stay." She would like to take a summer institute with other teachers on teaching writing with computers. "Getting paid is not as important to me as the opportunity to learn more about this subject," she says. However, it takes time, energy and initiative to write proposals for a workshop like this, time that Abby isn't likely to have available this year.

Abby believes that her district should make computers part of the school budget and not leave it up to the initiative of

teachers and community members to find unusual ways to make such an important educational tool available to students. She feels that too little money is spent on computers in her district: no money is allocated for hardware or software in the elementary schools. She believes there should be greater funding.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

Abby believes that "in the long run, teaching will be easier with computers," but that it will "take time to get adjusted to using them. Using computers will make students more self motivated, allow them to work independently," Abby says. "When they learn word processing their work will look more professional and be easier to correct."

The advent of computers has created a very special circumstance in schools: students are more knowledgeable than their teachers. "There are first and second graders who use computers at home who are more literate than I am," Abby says. She adds that "students who have computers at home, who are not natural leaders, may experience a boost of self-esteem when they are able to share their knowledge at school."

Abby looks forward to other computer-related benefits. She has heard that students who hate to write with a pencil like using a word processor. She has been told that students who are overwhelmed by the large classroom and all the distractions in it "really pay attention to that screen and do something with it." Abby believes that the immediate feedback that a computer can provide contributes to student learning. Moreover, she knows from experience that students learn in different ways. She hopes that having computers in the classroom can help her and other teachers provide different kinds of learning experiences for

students. Abby suspects the computer will be particularly effective for the visual learner.

The computer literacy requirement for high school graduation surprised many teachers and parents, but she expects it will force the district to give more thought to integrating computers into instructional programs. This, she thinks, will take time. She says, "I still think the general population doesn't have a very good feeling for what computers are doing in our lives."

Abby feels fortunate to be working in a small school where the teachers decided together to buy and to learn to use computers. She views computers as just one more opportunity to share with her colleagues. Looking ahead, Abby thinks that learning to use computers in their teaching could create an opportunity for her staff to serve as resources to teachers in a nearby school. This might be exciting for her staff who have never served as a model program for another school in the district.

Abby isn't sure what effect using computers has had on other teachers. However, she knows of a former math teacher who became the first computer teacher at the high school. The use of computers in teaching gave him a new lease on life, she says. "In fact, this is all the computer teacher talks about -- what his students did in class. He's really excited about it." Another teacher has told her that computers have made him "envious of younger people who are in the computer field. They seem to be doing pretty well, you know, and I guess I'm kind of

envious that maybe I was born a little too soon and missed out on some of this, and I feel maybe I've been in teaching too long to give it up. But if I get laid off, I'll probably look into the computer field."

Abby knows the district has not been equitable in distributing computers to all the schools. Further inequities exist because "some students have access at home," and "the main problem with computers is there aren't enough to go around." She asserts that the district moratorium isn't creating equity, as individuals and parent groups who are sufficiently motivated and affluent will find a way to put these tools in students' hands. Meanwhile, the district is attempting to deal with policies and strategies for integrating computers into classrooms before buying equipment or gaining experience using them.

Abby is aware of the difficulties facing the district. Computer scheduling is difficult. Training is important and expensive, and no one seems certain how to get teachers to feel comfortable using computers to teach. All of these questions are going to take time to work out. "I think it will be good when the district as a whole addresses the use of computers by the children and by the staff. And then assuming that they create some objectives, they develop a plan so that those can be fulfilled. I don't think you find computer phobia. I really don't. I mean we're living on the edge of high-tech here. I think that teachers particularly during the school year are so busy they need something created for them that's relatively easy

for them to attend. They're not necessarily going to seek it out."

Nevertheless, Abby is pleased with her own situation. A classmate, Gail Otis, a first-grade teacher, enrolled in the same graduate program at the local university, told her about her own situation. Gail had reluctantly taken a computer course several years ago when her district mandated that all teachers become computer literate. To her surprise she found it extremely interesting and immediately saw the educational possibilities. She took a course in BASIC, Logo, and Software Evaluation at her own expense.

She felt excited about taking computers into her classroom. Her district asked her to lead some computer in-service training for other teachers. But when it came time for the district to purchase the hardware, the computers were placed in a laboratory under "the lock and key of one person." As a classroom teacher she was unable to get access to computers for her own students. After complaining about her situation to Abby, Gail thanked her saying, "I'm glad to blow off some steam. It's been years now and my enthusiasm is waning."

TEACHERS' INFLUENCE ON TECHNOLOGY

Although the teachers in Abby's school decided to use money from a private gift on computers, decisions about technology purchases and policy are normally made by the school board. "I have a feeling that if I wrote a computer into my budget I would

be told that isn't an option! I'd be interested in getting computers into more elementary classrooms with [district] support."

Abby believes that computers should be used by every student from the learning disabled to the gifted. "All students like to use them," and they can be useful in all disciplines. "I can't think of any class that would be left out -- maybe gym!" she says. Ideally she would like to see a cluster of three or four computers in each classroom so that there is enough access for students to do really productive work with them. "If you have limited time and limited machines, the benefit you expect to get out of your assignment is not going to live up to your expectations," Abby warns.

The most compelling reason Abby gives for using computers in teaching is that "we're living in such a complex age and our kids have to make a lot of decisions. And most important they have to make decisions about what to do with their life after they leave school. They have to be educated to the computer so they will be able to include that aspect in their decision making. I'm already out of date in a lot of ways. If they leave school and still don't know about computers, I think it will be to their detriment."

Despite her great enthusiasm for using computers, Abby has one concern: "I think the greatest danger is if computers isolate people, cut back interaction between students and between

students and teachers." She says that if she saw that happening, she'd stop using computers.

LAURIE ADLER:

USING COMPUTERS IN AN ELEMENTARY CLASSROOM

`Laurie Adler´ represents a dedicated elementary-school teacher whose introduction to computers was filled with hurdles. Beyond being given a computer for her classroom, she received little support from administrators, minimal training, and limited software. Her colleagues also lacked her enthusiasm for tackling the unknown. "People were left ... too much on their own, and so if they weren´t curious at all, they just didn´t get involved." Despite the lack of professional encouragement, she met the challenge of integrating computers into her curriculum because of her belief that students should "grow up with technology and be familiar with it and put it to their best interests."

INTRODUCTION

Laurie Adler teaches first grade in an elementary school with approximately 625 students. The school is situated in a large town on the West Coast, with a predominately middle-income population. Last year, she had 26 students in her class, and was responsible for teaching them "everything" except art, music and gym. With a bachelor´s degree in elementary education and 14 years of teaching experience at the kindergarten and first grade level, Laurie believes she has considerable expertise working with children.

For the past few years, Laurie has had one computer in her classroom at all times, and also has had access to several floating computers ("if I´m aggressive ... I take it on a rollaway cart when nobody else is there, and then when they come for it I say we´re in the middle of using it, and I won´t give it back"). She and her students use the computer as often as they

can; she uses it daily and each child in her class uses it once or twice each week for about 30 minutes. Laurie thinks she would use computers even more extensively -- if only she had more time and training.

COMPUTER USE

Laurie's first exposure to computers was four years ago. She had just been hired by the school system she currently teaches in, and on a whim decided to take a one-day computer workshop. This experience left her feeling uncertain that she would ever understand how to use computers. Then, unexpectedly, she was given a computer to use in her classroom. Although computer use was not a required part of the first-grade curriculum, she felt she was expected to use this computer, so "it was just dive in and get wet ... I always made the commitment in my life that when I became a teacher [who] didn't want to do the new things or at least investigate them and give it a good shot, then I didn't want to teach anymore." Over the past few years, Laurie has gradually felt more at ease using computers. The discovery that "you can tell the computer what to do, and that's basically what all software is about was a wonderful revelation, that it's not some magical machine."

Currently, Laurie's school has 16 computers, most of them Apple IIes. The majority are located in classrooms, while several float throughout the school and are used mainly for administrative purposes. Within several years, the school aims

to have a computer in every classroom as well as a small computer lab.

Laurie wants her first graders to feel comfortable using computers, to become familiar with the keyboard, and to have respect for the equipment. "The first thing we do is learn respect for the machine; ... I open up that machine and let them get right inside it so that there is absolutely no fear or apprehension about what's going on in there." She also wants her students to acquire a good vocabulary "so when they're talking about a piece of the machinery I know what they're talking about. 'Don't say this little box, refer to it as the disc drive.' They know the difference between the CPU, the keyboard and that a monitor is not a TV." Laurie refuses to do things for her students such as boot the disk. The children have occasional accidents, but she finds that they adapt easily, much more easily than adults.

Laurie's instructional approach with computers is very flexible and is based on what she thinks makes sense for her students. The computer serves as a "learning station" in her classroom. "I've found that it just fits in with the way I like to do things during school ... Having a computer in the classroom helps me to keep more of an individualized approach to teaching." In addition to having individual students work on the computer, Laurie also uses the computer for whole class lessons and small group work. Her students use some math and reading software, but they use the computer mostly for writing. Using the computer,

the children have written short stories and poems far superior, she believes, to what they would have produced using paper and pencil. Laurie would like her first-graders to use the computer in other ways as well, but she hasn't had the chance to preview much software and it isn't readily available; the limited software in the school is shared among many classes.

Initially, Laurie found that having a computer in the classroom presented logistical problems: "There were a lot of interruptions in the rest of the class when these kids were working [on the computer]." She continues, "so what has worked for me is to have a master computer pal, a child on a rotating basis, who really knows a piece of software ... to whom those kids using the computer can go for questions rather than coming to me." Laurie adds, "I have to keep things very focused in terms of the kinds of projects we're working on to be sure that all kids have an opportunity to use the computer." Each week, she makes up a schedule to ensure that everyone will have at least one chance. "Sometimes it's more frequently and some kids will ask to stay after school to work on a project."

Laurie has noticed that computers encourage a sense of community in her class; students often choose to work together on the computer, and sometimes two children even share a chair. She also believes that computers enhance the curriculum. "Computers are another means of motivating students, another means of getting the point across ... they like the idea of pushing buttons ... color ... a picture to look at ... touch."

Laurie is convinced that elementary-school students should use computers in school. "Computers are going to affect all our lives very strongly. I think our students are going to grow up and need to be familiar with the pitfalls as well as the wonders of the computer. I think it's going to be such a strong instrument that they need to know how to be in command of the computer to even survive. They're going to have to know about computers." Recent technological advances, she points out, demand that students develop different kinds of problem-solving skills than before. "I'm very much against the mundane dittoed work, and I just don't think that it's very probable that any of our kids are going to have to divide nine trillion by 34,230, and do 15 pages of math. No profession is going to demand that. They might have to know the process, but they're not going to actually have to do that kind of computation in their lifetime. And I think that's a waste of their time. So I'd rather that they grow up with technology and be familiar with it and put it to their best interests."

In the past year, Laurie has begun using the computer for school-related activities -- such as preparing worksheets and keeping progress notes on her students. Recently, she discovered how easy it is to compose notes on the computer, messages that she can send home with her students and thus promote "useful communication" between school and home. She asserts, "I may never use a typewriter again."

Laurie does not have a computer at home but wishes she did. She can imagine endless possibilities for using one, enough so that her next big home purchase will be a computer. "I feel that I've reached the point in my life where I need a computer to help me get myself organized." For now, she often arrives at school early to prepare materials, and sometimes works late into the afternoon as well.

Many teachers in Laurie's school do not use computers in their teaching. Although her school has no formal requirement that teachers use computers, Laurie hopes she can prod other teachers to use them now that she herself feels more comfortable with them. She emphasizes that teachers need practice to become more confident. "I was afraid at first. But it's not that hard. You just need time and patience."

TRAINING AND SUPPORT

Laurie has had two training experiences using computers ("that's all that I had!"). She participated in a one-day class when she was first hired by the school system, and several years later took part in a three-day workshop. Both courses were offered by the school district to teachers on a first-come, first-served basis. There were no prerequisites, and the classes were free. Approximately 25 teachers participated in each course.

In the one-day class, the instructor gave a brief overview of computers in education and discussed different kinds of

software for elementary-school children. Laurie had to "hook-up" a computer and printer, and had some time to try out several kinds of software. She found the experience extremely frustrating, primarily because she has never felt at ease "working with machines." "I found it very difficult. It wasn't something intuitive for me at all ... I left and thought 'I'll never be able to do this.' " In addition, Laurie felt the instruction covered material too quickly and was not particularly reassuring.

Last summer, Laurie took part in a three-day workshop: the teacher discussed the history of computers, and let the participants experiment with educational software. Laurie was impressed by the instructor's excellent command of the material, and found her enthusiasm contagious. "She says you have to be very patient with this ... That really helped me a lot because it has given me a very positive attitude ... If I can't get it to underline or whatever, that's okay, because I'm here to learn. And I can just play with it or work on it until I get it to underline, and then I've really learned something I'll never forget. It doesn't mean that the teacher has to know everything because a lot of times in a computer situation people are learning together, and the students and teachers are learning together. I think that the main thing is the teacher's feeling of self-confidence, and the feeling that even though she doesn't know exactly what's happening right this minute she still has control over the learning situation, and we'll get it figured out

together." This kind of encouragement would have been extremely reassuring early on, Laurie says, when it was difficult for her to admit that her grasp of the material was shaky. Another advantage of this course, she adds, was that she was able to take home a computer for several weeks afterwards.

Although no monetary or status rewards are associated with knowing about or using computers in her school, Laurie says: "You know where the reward comes, it comes when children choose to stay after school, to come in at 8:00 o'clock in the morning [to work on the computer], that's where the reward comes, and when parents say that they appreciate the extra time that you've done, that's all, I really appreciate that."

Laurie belongs to a district-wide group of teachers who meet informally approximately once each month to discuss computer use. Although she is happy with this collegial resource group, she would like stronger support from the administration; she asserts that many administrators don't appreciate computers enough because they are "not knowledgeable enough." Over the past five years, Laurie has seen funding for computers go up in her district, but she thinks more resources should be allocated for hardware and software, and especially for training. She thinks that teachers are a little too timid sometimes -- they'll stay away from something unless they're encouraged. "I don't think there was the support and encouragement in the beginning stages of learning about computers. I think that more teachers would have gotten involved if there was that support ... People were

left, I think, too much on their own, and so if they weren't curious at all, they just didn't get involved."

A computer coordinator "who is just an extraordinary man" was recently hired by the school district. Laurie believes that the decision to have a full-time coordinator is a major step forward for the district, and she is optimistic that he will build computers "from the ground floor" up.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

Laurie's use of computers has changed in the past few years, from very occasional use ("a novelty thing") to much more frequent use. At first, Laurie experimented with the computer by playing assorted games; she gradually branched out, trying various educational software and word processing packages. Throughout this time, she continually reassured herself: "Not to worry, there's plenty of time to learn how to do this. These are little kids, they don't know that much, I just have to keep a day ahead of them. I can handle it."

Rather than feeling overwhelmed as she did four years ago, Laurie is now fascinated and "in awe of technology." She has also seen some other teachers learn to use the computer as a tool. Laurie knows of some teachers, though, who have a computer in the classroom and let it sit there, without ever using it. She blames the school's lack of policy for this situation. The problem, she explains, is that teachers are given a computer to use without receiving the necessary training and support.

Laurie thinks teaching with a computer is a little more difficult -- the computer makes her work harder. She has to try out software, and figure out the best way to use it in her lessons. This makes her planning and teaching more complex. But she believes she is a better teacher for all of her efforts.

Laurie believes that computers have had a positive impact on her students. Her first graders are always enthusiastic about using the computer. And they are learning that writing can be fun: "When they type their stories and get a print-out they can't believe they wrote it." She believes that computers help lengthen children's attention spans and teach children to be patient. They can exercise control over what they see on the monitor and, if patient, can get satisfying results. Moreover, by working together on the computer, her students are beginning to appreciate each other's strengths.

Laurie's use of computers has subtly changed her relationship with other teachers. She has surprised herself, at times, by talking with her colleagues "about things I've done in the classroom. I feel more self-confident in my job, and it has made me come across as more assertive and a stronger person as well as more positive." Laurie regrets, though, that the introduction of computers has created some divisions -- mainly between the older teachers who are close to retirement and the younger ones. Some teachers "tend to make excuses and pretend they don't have time" to use computers. Next year the district

will provide a basic beginner class for these teachers, which she jokingly calls the "Deathly Afraid of Computers Class."

Several teachers in Laurie's district have become computer coordinators or have computer-related summer jobs. Laurie says she would be "thrilled to death" if she could give a computer workshop, "to think that I knew enough about it to do that." She recognizes, though, that it is unlikely that she will be asked to conduct a workshop, and is uncertain whether she would actively pursue the coordinator's position on her own.

TEACHERS' INFLUENCE ON TECHNOLOGY

Laurie doesn't really know how decisions about computers are made in her district. She thinks that the superintendent "hands down" the policy, and the principals have some say in how money is distributed. She would like to play a larger role in making decisions (perhaps, "be a head of a committee"), and thinks this may be possible in the future.

Ideally, Laurie believes that computers should be used regularly by all elementary-school students and integrated into the entire curriculum as a learning tool. "The material that I use is open-ended; it gives the children the opportunity to control the machine and to create and problem solve on their own. I like the open-endedness of the things that I use on it. We don't really use it for games and things like that." She emphasizes that all students should have opportunities to use computers: "I'm very much against computers being used as a

reward/punishment system. It horrifies me." Laurie is not interested in designing software ("There's so much software out there, I don't know why I would bother."). She would rather spend her limited free time sorting through what already exists. The most compelling reason for using computers in the classroom, she says, is that "we have to prepare our students for the future and that future is going to revolve around technology, and students have to become comfortable with that technology and put it to work for them."

CHRIS JOHNSON:

USING COMPUTERS IN SPECIAL EDUCATION

As a teacher of learning-disabled high school students, `Chris Johnson´ represents someone who has used computers to change dramatically his teaching. His small classes enabled him to use the technology both for individual instruction and for building students´ interactive, vocational and study skills. His aim has been to "find software that fits the curriculum at hand" and to "embark on special projects that expand the curriculum." He reports that the classroom computer has also served as an equalizer: "It brought non-handicapped kids in touch with handicapped kids and had handicapped kids perceived as being competent in something, which is not often what happens with them." In his view, the positive effects of computers on the curriculum for learning-disabled students are just beginning to emerge.

INTRODUCTION

Chris Johnson is a teacher of the learning disabled in a large urban high school in a mid-Atlantic state. The school has an enrollment of approximately 2000 students in grades 9-12 and is located just outside the downtown district. Chris is responsible for teaching learning disabled, mentally retarded, physically handicapped, and speech impaired students, a position he has held for the past 10 years. His students range in age from 12 to 18 years. He holds a B.A. in psychology and education from a prestigious public university, an M.A. in special education from the local state university, and is working toward a Ph.D. in speech pathology, also from the local state university. He has state certification to teach special education and has been teaching for a total of 14 years. In

speaking with him, one is quickly captivated by a rather unusual blend of soft-spoken sincerity and outspoken political savvy.

Chris has used computers in his teaching since 1981 and, at present, has two Apple IIe computers in his classroom. In addition, he has access to 10 IIes in a lab setting in his building. This central lab is one of four in the school, others being devoted to word processing, computer science/mathematics, and business. Chris estimates that, altogether, there are 50 computers in the school. He makes frequent use of computers in his instruction (in about 1/2 of all the periods he teaches) and considers himself an extensive user of the technology.

COMPUTER USE

In 1981, with the encouragement and support of the district's newly appointed computer coordinator and other teachers of students with learning disabilities, Chris enrolled in a graduate level course on educational uses of the computer. The course was designed both to introduce the fundamentals of hardware and software and to demonstrate how these might be integrated into the high school curriculum. With this experience as a spark, he pursued an emergent interest in software development for learning disabled (LD) populations, enrolling in district workshops and pursuing computer studies as part of his Ph.D. program. While he saw the possibilities of using computers for individualized instruction and enhanced social interaction with his LD students, Chris also recognized that, in order to be

serviceable for these students, available software would need to be adapted for special populations or that new software would need to be "invented." He observed that, while some district personnel "wanted me to learn LOGO, ... my kids were never going to deal in LOGO. It just wasn't a functional skill." Furthermore, "it was embarrassing to have kids using elementary school software when they were in high school. They just don't want to deal with apples and clowns when they're high school age, although that might be their reading and cognitive level."

The project, then, was to develop software that was both "user friendly" and suitable to the structure and pacing of an LD classroom. Chris responded to the need by writing a "mini-grant proposal to adapt those materials" that appeared most promising for special educational use. He spent time during one school year (after school hours) and two summers working on the project, seeking help from computer professionals, LD colleagues, and several high school honors students. He was so excited by the challenges of computer technology that he wrote another grant proposal aimed at implementation and was awarded two Apple IIe computers for his classroom. This enabled him to get hardware into his classroom well in advance of its introduction into most classrooms in the district. While the school has made a substantial investment in computer technology, and while there have been grants from outside agencies (including a gift of computers from a leading computer manufacturer), the LD

department has had to compete for hardware with other departments, especially business, math, and science.

The presence of computers in his classroom, coupled with his continued training and his purchase of a computer for home use, enabled Chris to accelerate the pace of his experimentation and allowed him to become comfortable with the role of technology in his curriculum. He appreciated the "flexibility" of having computers both in a lab setting and in his classroom (which, as an LD class, is limited to 10 students) and was able to integrate their use into many phases of his instruction. Chris had recognized from the beginning that "All the logistical problems ... need to be dealt with so that they're at a comfort level appropriate to the individual teacher." He expressed mild dissatisfaction with the school's system for assigning time in the computer lab and indicated that he would like more access. The district's computer coordinator meets with school administration and department heads prior to each term to decide who gets time in the lab. Given the competition for these spaces and the relatively small size of the department (in number of teachers and number of students), Chris is not always able to achieve the access he would like (two hours of lab time per pupil, per week). But, these organizational constraints have not proved insurmountable. Chris has become especially adept at the politics of negotiating lab time and other computer-related issues. "I think when...you know which people to talk to and who has a little power or who has a little influence with a school

committee member -- this is the way of the world." When he realized that the business department cornered much of the available lab time, he decided "to get a friend in the business department." Two of his time periods in the lab are a direct consequence of this "friendship."

Chris has devised a number of uses for the computer in his LD classes; in fact, it is a central component of his teaching approach. His aim has been twofold--one, to "find software that fits the curriculum at hand," making the necessary adaptations, and two, to "embark on special projects that expand the curriculum." The small size of his classes has made it possible to use the computer as "the focus for the whole class for demonstrations and decisionmaking, on down to individual use." For many students, learning just the elementary keyboarding strokes is important for the development of impaired motor skills. While, in most cases, this kind of improvement is simply a byproduct of more demanding uses of the computer, for one of Chris's students it is an end in itself. This student has virtually no control over the movement of her limbs but is able to initiate computer inputs with a small wand fastened to a headpiece. Here, the most elementary use of a computer provides new ways of reaching out, of communicating with teachers, parents, or other students. As such, the computer plays a significant part in helping the LD student cope with his or her environment. Chris tried some drill and practice programs to

promote mastery of basic concepts but now steers away from them; he observes that they "were not particularly motivating."

But, beyond these fundamental uses of the computer for special students lie other uses that Chris is beginning to explore. For example, for the past three years he has used the program Printshop as a business venture for helping students develop vocational and social skills. Students prepare newsletters, banners, and other printed matter which they then sell within the school or wider community. He has also found classroom uses for Quations (a "Scrabble game with numbers and operations"), Crossword Magic, Story Tree, Math Blast, and various data base, graphing, and spreadsheet applications. He has worked closely with teachers in the English component of the LD program to help students acquire word processing skills. "With guidance and encouragement they will use the computer for word processing." Chris reports that these skills have proved particularly important for improving student self-esteem. For the first time, the LD student could produce "something that ...come[s] out legible, that ... come[s] out looking like it could be put in a book." This finished product can be shown to parents or friends and is often the source of great personal pride.

Chris has several reasons for using computers in his class. Basically, he views the computer as a "tool that can do many things." For some students it functions as an environmental coping device. For almost all it seems to be a great motivator;

students migrate toward the computer when given the chance and are often happy to stay after class to continue work in progress. But, perhaps the most telling of Chris's reasons is that the computer has the capacity to play the role of "equalizer" among between LD students themselves and between LD kids and non-LD kids. "I've found that ... with the special ed population ... the computer acted as an equalizer. It brought non-handicapped kids in touch with handicapped kids and had handicapped kids perceived as being competent in something, which is not often what happens with them." Chris has instituted a peer buddy system to promote this process. He pairs an LD student with a mainstream student, and together they work on computer activities. "My retarded kids could whup those regular kids with some of the memory games and some little spelling games and things like that. I think it was one of the first times that regular kids perceived this normal competency level in handicapped kids." Here, then, the computer is a tool that allows kids to work around their disabilities and find common ground with other students in the school.

Chris also believes that, later in life, many of his students will find themselves in situations where they are called upon to interact with machines. Whether in jobs where they perform data entry procedures or in circumstances where they rely on mechanical interventions for coping with disability, LD students are likely to draw upon their earlier experiences with computers and other technology. In short, he thinks computers

may present the handicapped learner with opportunities for future success along whatever dimensions this success may be measured.

Outside of class, Chris uses an Apple IIe computer for preparing class assignments, for entering student grades on a spreadsheet, and for previewing software that might eventually be adapted to LD uses. Apart from these school-related uses, he prepares graduate school papers with word processing. Other teachers in the school use computers, though few use them as often or for the same reasons as does Chris. He recognizes that his teaching challenges are different and that these invite different ways of using the computer. On the whole, however, computer use "is growing; more and more teachers have taken courses; more and more teachers are purchasing computers." Within the LD department, Chris's use is more extensive than that of his colleagues, and others come to him for ideas and support.

TRAINING AND SUPPORT

Chris has had extensive training in the use of the computer. He has taken four graduate level classes at the local state university (programming, software applications, software design, and educational uses of the computer) and two district sponsored workshops (a general introduction to computers and classroom applications of the computer). Each of the university classes awarded three credits and lasted a full semester (15 meetings, 3 hours per meeting); Chris attended during summers and in the evenings. The district has reimbursed Chris for three credits of

his graduate work on computers; the remainder he has paid himself.

Initially, these graduate classes focused on the development of programming skills, "a focus which," Chris maintains, "...most teachers ... need to steer away from." Learning to program in BASIC and LOGO was challenging, Chris reports, but he was not shown how to integrate this skill into the curriculum, especially the LD curriculum. The classes combined lecture and hands-on experience; students were teamed on 15 Apple computers in a lab setting. The strengths of the university training resided primarily in its faculty -- "a very dynamic professor who encouraged students to bring in their areas of expertise," another professor who "had background in software development and design," and a third who "was a wizard in terms of educational design, making sure an educationally sound idea could be translated into educationally relevant activities." In addition, Chris mentioned the virtues of a course requirement, in one of the later classes, that students create "some educationally sound piece of software."

The district-sponsored workshops were related to a hardware grant from a major computer manufacturer. Lecturers and facilitators were drawn from the local university, which was allied with the computer manufacturer in a wider collaborative effort. The classes were held at the high school's lab and covered elementary applications and programming. Sessions were held after school hours and on weekends, for a total of 15 hours.

Chris felt the workshops were very well organized and presented but recognized that, had he had no other training, there would have been sizeable gaps in his understanding and a substantial amount of self-instruction left to do. For Chris, the strength of the workshops lay in listening to teachers frame their professional concerns about the integration of the computer into the classroom.

Many district and school site administrators -- especially Chris's principal and the district computer coordinator -- are supportive of computer use, as are other teachers in his department. Recently, the district initiated a three-year plan for computer technology aimed both at increasing hardware and software availability and at providing more sophisticated on-site support services. A new support position for LD computer use was approved by the district office as part of its technology plan, and Chris, given his experience and interest in computers, has applied for the job. The position is full-time and would require that Chris leave his teaching post. He would work with other LD teachers throughout the district as well as with central office personnel. Chris observes that, in the absence of on-site specialists, it is imperative that there be central office personnel "who are accessible, who have the time to be able to attend to those major concerns of the classroom teacher." The district will pay for teachers' attendance at conferences, and even provide them with "mini-sabbaticals" if important professional meetings conflict with teaching obligations.

Though teachers in Chris's district receive no direct, tangible rewards for using computers, there are several ways in which they can convert their skills into professional gain. Since payscales are tied, in part, to the number of college credits a teacher accumulates, a teacher can secure a salary increase by completing computer classes in accredited programs. A teacher with a thorough background in computers might also be hired as an instructor in the district's summer computer training program. And finally, with the advent of a new merit pay system in the district, Chris believes it is likely that many teachers will advertise their computer training and skills as evidence of continuing professional development.

High on Chris's wish-list are more computers for his classroom, a large screen monitor for class demonstrations, and additional support for software review and lab scheduling. He would like to see more money spent on computers, but he also realizes this may be unrealistic, given competing demands on the district's resources. The issue that stands out in his mind, however, is the need to provide more and better support services to answer teachers' technical and professional questions about computers in the classroom.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

Chris claims that the presence of computers in his classroom has made a substantial difference in the way he teaches. "It changed my teaching dramatically and gave a very wonderful boost

to the kinds of things I wanted to do." He observes that some of the programs he uses, e.g. Printshop and Quations, have led into content areas he wouldn't otherwise have explored. He is "much more willing to try new types of ideas, the innovative types of things such as [the business with Printshop]." The adaptation and invention of software programs for special students has also contributed to changes in his teaching. It has allowed him to concentrate on students' control over their own environment and over their own learning. In the past several years, Chris's use of the computer has "moved more toward applications," away from drill and practice and educational games. This shift, not atypical for computer-using teachers, is, in large part, a consequence of his "growing trust and excitement in the possibilities" of computer use with LD students. He also mentions the importance of having a computer in his home for purposes of learning and experimentation. "Each year I add one new major software [application] to my repertoire ... something I use personally." By first becoming comfortable with software at home, Chris was able to be more attentive to student needs and curriculum possibilities in the classroom setting.

Chris reported that teaching with a computer is "different," at once easier and more difficult. "The computer, in and of itself, creates different sets of problems." "From a logistical standpoint it can be more difficult, because there are other factors that you have to be concerned about. A teacher who plans to use the computers for a given period has to be willing to be

flexible. I think flexibility is forced upon you by the computer." He continues, "It's easier in that you might not have to do quite as much motivating; good programs provide structure, so that once you get a student ... into interacting with it, your role will become more that of an observer or an involved participant rather than that of the authority figure. The teacher can be a learner right alongside the student instead of being the presenter of information." Chris also described how integration of the computer into his teaching has followed a natural cycle. "I see things becoming easier when I understand the software better. The first time I use the software it takes ... forever to figure out the kinks, and then, the next time, it's that much easier. But, then, being self-punishing, I'll try a new piece of software that'll make [things] a little harder [in the short run], but that's to make it easier in the long run."

Chris has experienced some changes in his relationships with other teachers as a consequence of his using computers, changes which he construes as positive. Shortly after he introduced computers into his classroom other teachers in his department and in other departments in the school dubbed him the "resident expert." "People would come to me for advice and I did some training of people in my own department." Chris enjoyed this role, and other teachers seemed to appreciate his efforts on their behalf. The computer has created a new common ground for teachers, one that leads to more extensive collaborative activities. Chris's excitement about the uses of computers in

teaching and his preliminary work with other teachers made him a natural candidate for the district's new LD computer resource position. His reasons for applying are clear. "I was looking for a change, looking for something fresh, ... looking for a way to be learning while teaching. Teachers ... need to feel challenged; they need to feel they are improving their own skills and capabilities while on the job." He views the new post as an excellent vantage from which to promote teacher involvement in the development and integration of computer technology in education. For instance, he revealed that the teacher's role in previewing software "is a very key component to my feelings about the implementation of technology, now and in the future. Once the hardware's in place [and] the software's being developed, ... if we put it in the hands of teachers who have a little bit of background and a little bit of creativity, the possibilities are almost endless for the types of things they can do."

Chris was positively effervescent in his description of the impact of computers on his LD students. He witnessed, for example, that changes in his own role as teacher, his increased openness to learning, paved the way for changes among his students. "When a teacher can shift roles and show the ... humanness, as it were, for some students, that's the magic key that turns on their willingness to try more things in the classroom." The computer is a tool that students can use to discover and display positive qualities, to open new channels of communication with their fellow learners. It can actually "turn

around" the educational experience for students who've had difficulty with the social dynamics of the classroom -- making friends or working with others. "The social aspects can really be used, especially by special ed teachers." Chris explained how, in certain respects, the computer has functioned as a medium for improved personal interaction. "I've had romances form around the computer; for some of the students it was a deflection of having to work that difficult interaction of male/female roles." The upshot of these observations, then, is that the use of computers in Chris's LD classroom provides additional options for developing academic and social skills.

Chris felt that the effect of computers on the LD curriculum was just beginning to emerge. Most of the available educational software has been written for mainstream populations, and the utility of general purpose applications software (such as word processing or data bases) is only now being explored. His main point is that using the computer with LD students promotes flexibility in both teaching methods and the curriculum, serving both as a means for individualizing instruction and as a means for initiating group work or demonstrations.

Chris didn't believe that inequity in computer resources was a major problem for his district. He maintained that "there is a lot of conscientious behind-the-scenes work to make it as equitable as possible." Of course, this effort doesn't totally relieve the problems surrounding access to computer labs, nor does it diminish difficulties growing out of independently

obtained resources or equipment (through grants or gifts). Local Parent Teacher Organizations can and often do purchase additional hardware for their schools, and this is something over which the district has very limited control. Within his class, Chris has noticed that boys are "slightly more likely" than girls to use the computer. Yet, "with encouragement, and with a little extra attention," girls, he found, would get involved with the technology.

TEACHERS' INFLUENCE ON TECHNOLOGY

Decisionmaking in Chris's district works "from both directions, from a centralized approach and from a school-based approach." The school board, the superintendent, and the district computer coordinator make many of the district-wide decisions involving purchasing and resource allocation. But, even at this level, teachers can influence decisions--they "can push on the people who are making the decisions, try to affect things at their own school." At the school-site level "individual teachers who have a specific interest in computers can usually find a way" to realize their objectives. Here, Chris points to his own decisions to use computers in the classroom and to bargain for more time in the computer lab. He believes that, with the support of his principal and departmental colleagues, he has had adequate opportunity to individualize his use of the computer. In this environment, teachers "can have a lot of say in what software is used." Chris discusses software selection

with other teachers, drawing on their expertise in English or in math, for example, before deciding on a word processing program or a piece of pre-algebra software.

Though Chris has no serious objections to procedures now in place, he acknowledges that he would like to play a larger role in the district's decisionmaking about computers. This desire was a key factor in his choice to apply for the job of LD computer specialist. His experience in the classroom and his commitment to the importance of teachers' voices in the educational development of computer technology make him a distinctive candidate for the post. "I think I have a good sense of what teachers need, the kind of support they need in a classroom situation, and I'd like to try to sensitize those people who have been making decisions about hardware and software in the areas of teacher training and the extent of teacher support." The message that Chris returns to again and again is that teachers must not be cut out of the decisionmaking loop, that they should be centrally involved in decisions regarding software and the integration of computers into the curriculum. The most effective strategy for promoting substantive computer use, Chris maintains, is "local control with guidelines and support provided by centralized folks." "You have to bring your teachers along at the same time you're bringing your computer program along."

Chris believes computers should be seen as a powerful tool in the teacher's kit. No two teachers will make precisely the

same use of that tool, but this versatility is what makes the computer so powerful for educational purposes. "Computers will find a variety of niches--from word processing to programming to applications to drill and practice to simulations." Given freedom to experiment and appropriate support from administrators, Chris is confident that teachers will find educationally sound uses of computers in their classrooms. For LD instructors this room for experimentation is particularly important, since existing software requires careful review and adjustment. Along these lines, Chris would like to see software developers design their products with an eye toward effective individualization or customization for special learners. This "template" approach to software design would make the computer a more effective tool in the LD classroom.

Chris insists that the most compelling reason for using computers with special education students is "that they work." They function as a multi-purpose "coping mechanism" and as a catalyst to better social interactions in the classroom. In the LD classroom, these are important features of academic success. The most compelling reason for not using computers was, in Chris's mind, not very compelling at all. This reason, simply stated, is expense. Computers are costly, as are the training and support that make them worthwhile additions to the school program. A school or district must be willing to incur the costs if they're to make effective educational uses of computer technology.

CAROLYN HEMENWAY:

TEACHING COMPUTER SCIENCE AND COMPUTER LITERACY

'Carolyn Hemenway' depicts an enthusiastic high school computer science and computer literacy teacher who has limited resources to draw on. Her computer lab is one of two in the school used by both students and teachers. A former math teacher, she decided to change roles because computers can teach "lifelong skills of problem solving and teamwork." Due to a state computer literacy mandate, basic decisions about computer use originate with administrators far removed from the classroom. "Typically, though, the people who make most of the decisions ... don't understand what computers are all about." Although her school district offers useful training courses, it lacks adequate funds to repair and replace equipment, send teachers to conferences, and buy supplies. Despite these drawbacks, she would rather teach any subject with "a computer or two or three or ten in the classroom."

INTRODUCTION

Carolyn Hemenway is a computer science and computer literacy teacher in a downtown high school in a large southern city. The school has 1200 students, with a heavy minority enrollment. Carolyn has 15 years of teaching experience, with three in her current position. She has a masters degree in math with additional graduate hours in math, computers and educational administration.

Carolyn's classroom is a computer lab with 18 Apple IIs. She uses the machines everyday for the majority of each period and considers herself an extensive user.

COMPUTER USE

Carolyn taught high school algebra and trigonometry for 12 years before starting her job as a computer science teacher three years ago. She had started tinkering with computers in the late 1960s, when as a self-confessed "gadget freak," she ordered one by mail and taught herself to use it. Before long a computer company in town began to offer courses, and she arranged to take one. She also took several courses at the state university, so when the state mandated that 20 schools offer computer science and computer literacy instruction in 1983, she found herself in a good position. Her school district provided further training for her current post. She knows of two computer science teachers who crossed over from English or drama backgrounds, but most, like her, have math backgrounds and were formerly math teachers; as many as half still teach math along with computer science.

In addition to the 18 Apples in Carolyn's classroom, her school has a lab in the English department with about a dozen computers used mainly for word processing. The science department has several more computers which they use for simulations. Most classrooms do not, however, have computers. The school office is equipped with an IBM PC for keeping records on attendance, discipline problems, and the lunch program. There's also an Apple in the teachers' room for faculty use in preparing worksheets, tests, and so on.

Carolyn finds the lab arrangement acceptable for her school's current needs, but she hopes eventually to integrate computers more fully into subject matter instruction. When that happens, she foresees a need for computers in each classroom as well as in the labs. She doesn't expect that to happen quickly, though, given the continuing shortage of trained people and good software. Right now, because the school budget is tight, it's tough to get new hardware or even to maintain the current equipment they have.

Carolyn's state requires that all students take computer literacy (a half-year course) or computer science (a full-year course) before they graduate from high school. Her computer science course is the more difficult of the two because it emphasizes programming as well as the applications that she teaches in the computer literacy course. As a result, computer science tends to get high achieving, more motivated (usually college-bound) students; computer literacy draws students with a wide range of abilities. Carolyn's initial goal in both classes is to introduce students to the computer and dispel any fears they may have. She finds this less and less necessary, however, because they now receive so much more exposure to computers at the elementary and junior high school levels.

When she's introducing a new concept or skill, Carolyn usually keeps students together for a whole-class demonstration at the beginning of the period. For this, she uses the lab's large screen monitor. Some students pick up quickly on the new

material and feel ready to go to the machines to start working on their own. Others stay for a second explanation or demonstration. If some students remain confused after several explanations, Carolyn pairs them with those who seem to be working successfully. Then she circulates around the room, talking with students, answering their questions, and making sure all students -- not just one member of each pair -- are working and getting what they should from the lesson. Once students in the computer science classes can write and debug simple programs, she assigns them longer, more complicated projects like writing a program that tallies votes for class officers. Sometimes, for a project like that, she'll ask different groups to write subroutines and then combine them. Carolyn does follow a textbook, but she throws in extras like high and low resolution graphics to hold student interest and to expose students to a wider range of computer applications. The curriculum for her computer literacy course calls for some elementary programming, but most of the semester is devoted to teaching keyboarding, databases, word processing, flowcharting, spreadsheets, and so on.

Carolyn uses the computer because it's essential to her courses, but she is convinced of its importance for students. She believes the computer can teach "lifelong skills of problem solving and teamwork and provide kids with a sense that they can reach levels of success they might not have been able to before."

Carolyn also uses computers at home. She still has the one

she ordered by mail in 1969 and has since purchased an Apple II that she uses for everything from word processing to keeping track of her recipes. She does some of her lesson and test preparation and gradebook chores at home too, since it's hard to find free moments to do them at school. She knows of other teachers in her building who also have computers at home, but she's sure that she uses one more often than most people, for both school and home use. She sees some teachers in her building as downright resistant: they view computers as one more demand on oversubscribed instructional time, or they're close to retirement and unwilling to learn something new so late in the game.

TRAINING AND SUPPORT

Carolyn was self-taught at the beginning. She enjoyed experimenting on her own and figuring things out as she went along. She used the manuals, bought lots of computer magazines, and "called around for help" to fill the gaps. After a while, she started taking courses and workshops wherever she could, sampling everything from state university courses in programming to training offered by Tandy Radio Shack. Overall, she characterizes her training as about half self-taught and half formal instruction.

Her school district offers courses regularly after school and during the summers. These are usually given in the district computer lab, and Carolyn rates them highly. Teachers get a lot of hands-on time on the computers and good relaxed instruction.

The only weakness is that sometimes the workshops try to squeeze too much into the sessions and participants wind up feeling rushed. Most of this training is free, though occasionally there is a nominal charge of $10.00. Teachers who want to receive graduate credit can pay an additional fee to do so. Even without graduate credit, the workshops and courses grant in-service credits that count toward salary increments.

Carolyn thinks most of her training has been relevant to her teaching. Some of the most useful learning comes from informal exchange with other teachers who attend workshops; for example, at one recent workshop, she learned about adaptive equipment that has helped her teach a handicapped student to use the keyboard more accurately. She points out that the district lab courses are geared toward teachers. This often gives them an edge over university offerings: "University professors typically don't know what's going on in the classroom and their courses reflect that inexperience. So they do what they can, which is to teach you about the technical details of something."

Carolyn also does some training herself. Informally, she provides help to teachers in her building who want it, and from time to time she teaches the computer literacy course offered by the district for teachers. She enjoys teaching teachers almost as much as teaching students, especially because she likes trying to help them over their fears and worries about technology. "As I define it, the bigger part of the problem of bringing technology to schools is a psychological one. People make

decisions about computers without really knowing what they are. And there are very few mechanisms in schools to disseminate skills because historically teachers haven't really developed many more skills than they had when they arrived. So the real problem is not the technology itself, but to build the infrastructure for disseminating these skills to teachers who aren't used to asking for or giving help."

Carolyn's district provides good support for computer use in some ways and is lacking in others. On the plus side are the services offered by the district lab. Their courses cover a variety of technology-related topics and are taught by knowledgeable and experienced teachers. Lab staff will also come to the school to consult with teachers or do on-site workshops if requested. The limitations of the support system stem mainly from the district's tight budget. No money is available, for example, to pay teachers to attend conferences or buy equipment. The district is even reluctant to give computer teachers release time, because they are in charge of so much expensive equipment, and substitutes are scarce. Teachers also lack adequate supplies, something Carolyn feels keenly by the end of the year when she is buying things out of her own pocket to keep the lab running.

The district pays Carolyn a $2,000 stipend beyond her regular teacher salary to oversee all the equipment, to purchase all computer-related supplies, and to help other teachers who request it. She knows that some teachers are envious of that stipend,

but she doubts they're envious of all the work that goes along with it. The only other extra compensation she's aware of is to teachers who work on special projects during the summer; for example some teachers are working this summer to revise the district computer literacy curriculum.

Carolyn belongs to a district-wide computer network that connects all schools, the district lab, and the central office. The electronic network is used most often for sending inter-office messages and for sharing administrative data, although Carolyn uses it to communicate with the district lab and with computer literacy instructors in other schools. She is working to get a student network set up, too, so that all students can contribute to and have access to a common database -- and so that things like the current inter-school newspaper don't have to be done on the sly on the teachers' network!

Carolyn thinks funding in her district is too low. The district seems to have scaled back on the financial commitment it made when it first introduced computers. Now it's only the schools with links to private industry, magnet programs, or rich PTAs that are getting new hardware and software.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

Carolyn thinks the main effect of computers on students has been on motivation. Kids are curious about computers and eager to spend time on them. She finds they're more open-minded about work on the computer -- fewer knee-jerk moans and groans about

assignments and requirements. Sometimes she has to hound them to get them out of the classroom at the end of the period. She thinks the computer appeals to them because they can work at their own pace and fail in private. They take pride in being able to do something that a lot of their teachers can't do. For many disadvantaged students and students of limited English-speaking ability, the computer provides an important opportunity to demonstrate skills and to receive acknowledgement. In most schoolwork, they're the dummies, but with the computer they get a second chance," she says.

Computers haven't really changed Carolyn's teaching style, but she has adapted and incorporated the technology, so that where she used to demonstrate on a blackboard, she now does it on a microcomputer screen. She also finds she can tutor more, moving around the classroom as students are working on assignments. Sometimes she feels like a coach and sometimes like a referee. She gets to know the students better with this close contact, and with more information about them and their learning she feels better able to plan for and meet their needs.

She finds that more and more she is trying to integrate what she does in computer science and computer literacy with what students are doing in their other courses. She has the ninth-grade science text on a laser disk now, and tries to integrate word processing instruction with the science modules, for example. A database, too, "has to be about something," so she might choose a topic related to, say, the social studies

curriculum. This has led her to learn a lot about the content areas that she wouldn't have otherwise learned and to have more contact with subject matter teachers.

As far as relationships among students are concerned, Carolyn is convinced that working in pairs and small groups has a positive effect; even those who feel awkward at the beginning usually come around. She has to be careful though, because a few students tend to become dependent, always deferring to their partners and asking others to help them write their programs or debug them. "I haven't figured out how to solve that one yet," she worries. "It's subtle."

Carolyn has also seen effects on her own relationship with students. She says she has always been close to her students and been able to communicate with them, but the computer enhances that rapport. "When you have to go around to kids individually while they're sitting at a machine and lean over to them and talk to them that up-close, some physical barriers are broken down, and some mental and emotional ones as well." She views this as an advantage, but she recognizes that "teachers who do not want to break those barriers are not going to want to use computers."

The introduction of computers into education has definitely made the teaching profession more exciting and challenging for Carolyn. She loves teaching and would keep doing it regardless of technology, but she'd rather teach any subject with "a computer or two or three or ten in the classroom!" For her, computers make teaching more fun. It's just as much work, but

the rewards are greater because it's easier to motivate students and engage them in learning. She finds teaching with computers more difficult in terms of classroom management -- keeping track of all the equipment, manuals, disks, and so on. She thinks teachers in training should get a lot more classroom experience with the potentially overwhelming logistics of getting a whole class booted up at once, dealing with disastrously-timed equipment failures, and other problems. These things soon become second nature, but until they do, they can be a nightmare and make a teacher ineffective.

For the most part, working with computers has made Carolyn's relationships with other teachers more enjoyable. She serves unofficially as a resource person for others in her school, and this has brought her into close contact with some colleagues whom she barely knew before. In general, she likes her role and doesn't find teachers' requests intrusive. She sees it as an opportunity to spread her enthusiasm about teaching with computers.

Computers have led to new roles for some teachers. She herself is an example because she left the math classroom and became a computer science teacher. That has also led her to opportunities to train other teachers. She knows of at least two teachers who avoided Reduction in Force (RIF) to reduce the school budget because they had computer skills and could be relocated to positions that involved computers; in one case the teacher moved to a district lab position and in another an

English teacher was appointed assistant principal, a job requiring extensive use of computers for scheduling classes and keeping school records.

Carolyn has witnessed few significant effects on the curriculum thus far. Of course, new courses like computer literacy and computer science have been created, and some of the business courses have integrated computers and boosted their enrollments in doing so. A few math and science teachers are using subject matter-related software in their courses, and the English department has incorporated word processing into composition instruction, but there's been no major integration of computers into the overall curriculum as yet. For math and science, good software is often unavailable; even if it existed, those classrooms currently have too little hardware to use it extensively; and even if that problem were solved, teachers would need substantial training to mesh the software effectively with the curriculum they are responsible for teaching. She has noticed some marginal effects on the curriculum: instructional objectives in the district guides are being rewritten to reflect the presence of computers, and new textbooks often arrive with computer-based exercises at the ends of the chapters.

Carolyn does not feel that computers and computer resources are distributed equitably in her district. She knows that some schools -- especially the district's math and science magnet schools -- get more resources than schools like hers that take all students and have lots of at-risk kids from disadvantaged

backgrounds. The district doesn't blatantly give more money and attention to the magnet schools. The inequities are more subtle and indirect; for instance, the magnet schools are hooked into school-business partnerships that bring in all sorts of extra equipment and training for teachers. Sometimes this is because magnet school principals have taken the initiative to go to outside sources for funding. Whatever the reason, the result is that kids who are higher achievers and from middle- to upper-middle-class backgrounds get more access to computers.

TEACHERS' INFLUENCE ON TECHNOLOGY

Because of state mandates for computer literacy instruction, some very basic decisions about computer use in schools are made at the state level. Then the district administration makes another "thick layer of decisions," which Carolyn finds problematic because people at that level "aren't close enough to the classroom to make decisions for us without consulting us, which they sometimes do." At the building level, a lot depends on the principal. Hers is good at soliciting teachers' opinions and considering them in making decisions, but she talks to teachers in some schools who feel they don't get listened to. In some schools the channel is from teachers to department chairpeople to principal and on up in a vertical game of telephone. This decisionmaking structure can lead to the misinterpretation or distortion of teachers' messages. "Typically, though, the people who make most of the decisions in

setting up the school don't understand what computers are all about."

Carolyn hopes that eventually computers will be integrated across the curriculum. She believes all students should learn at least the basic utilities -- word processing, spreadsheets, databases -- and that the regular curriculum should provide opportunities for teachers and students to use these tools to enhance the coverage of subject matter. She would love to write software for uses that are more imaginative and creative than most of the commercially available stuff she is familiar with. Ideally, she thinks there should be a few computers in each classroom as well as a lab where teachers could bring their students for whole-class work. This lab should have a technical assistant who could help with equipment and software the way librarians and media specialists help in their particular areas. And teachers need training to use software creatively -- drill and practice is fine, but computers can be used for so much more. In a sense Carolyn believes they prod us to redefine what we want kids to learn and how.

Carolyn cites two compelling reasons to use computers in education. One is that computers are everywhere now -- from auto garages to libraries, offices, and kitchen appliances. Kids need to know about them and feel comfortable with them. Students know this and will eventually demand it. The second reason is their incredible motivational power, especially for kids who have been turned off to other modes of learning. She has seen these

students experience a new sense of success and control over their own learning. "We don't need to use computers just for the sake of using computers. We need to use computers because we can improve schools, reach kids with learning styles that could not be reached by the traditional teacher-centered model."

For Carolyn the most compelling reason not to use computers has to do with a combination of money and accountability. She thinks it's very hard to know whether we're getting a satisfactory return on all the money we've poured into equipment and teacher training. She also sees knotty equity and management decisions about who gets what, and how to keep hardware and software up to date. The financial demands go beyond the initial outlay to include expensive upgrading and updating as well. She thinks it would be a shame if all those resources result in nothing more than mechanized drill and practice.

MARILYN GORDON:

INTEGRATING COMPUTERS INTO THE SECONDARY MATH CURRICULUM

A veteran secondary school math teacher, 'Marilyn Gordon' characterizes someone who has made extensive use of computers in the traditional curriculum. Her use evolved from programming to "picking up ways to integrate software, to actually developing the mathematical concept." The computer has influenced her teaching style, prompting her to employ more of a discovery approach and be less teacher-centered in her instruction. She also now covers more material and consequently can pose more difficult problems. She believes, however, that teachers must guard against letting technology appear to be a cure-all for every situation. She wants to foster the students' interest in computers while maintaining their realistic expectations of what computers can and cannot do.

INTRODUCTION

Marilyn Gordon has been teaching mathematics for 21 years in a suburban high school of 1,100 students in the Midwest. She holds a bachelors degree in math and has 70 hours of credit at the graduate level.

Marilyn first became interested in computer technology about six years ago after reading several articles in trade magazines. She then took some programming courses and bought a computer. At first, she thought she would be heavily involved in creating her own instructional software, but she quickly found out that she did not want to be a programmer. Instead, she began to use commercial software, mostly drill-and-practice programs designed for math classes.

As the first person in her school to use a computer in the classroom, Marilyn was selected by her school in 1982 to be a

member of a 3-person team (one science and two math teachers) to visit different schools within and outside the district to see how computers were used. In these schools students were taught computer literacy which included such things as the history of computers and keyboarding skills. By that time she was beginning to feel that the computer should be integrated into the curriculum and not viewed as a separate subject. Few of her colleagues agreed with her. When a new curriculum coordinator was hired, his first job was, "...to make her think like everybody else." But instead, she succeeded in converting him to her approach.

COMPUTER USE

Marilyn no longer uses drill and practice software which she refers to as "glorified electronic work-sheets," because many students become bored after using them a few times. When Artificial Intelligence plays a larger role in the design of this kind of software, she believes this kind of software may improve; meanwhile, she wants her students to learn concepts through inquiry and problem solving. She prefers to give assignments, "...where you can create some sort of open-endedness." To this end, she now uses The Geometric Supposer which allows students to make hypotheses and then test them.

She wants students to know that knowledge is "a unified thing" and that math applies to everyday experiences (for example, interest on loans); she sometimes uses computer games to

achieve this goal. She says, "I use computers to teach lifelong skills of problem solving and teamwork." She also uses the computer to do things that could not be done any other way. "I can't show on a blackboard a thousand balls dropping through a triangular grid," she says. "And to get a distribution, I want a graph to talk about theoretical and experimental probability. So I use computers a lot for simulations."

She recognizes that many of the programs she uses with her math students require a different level of skill, a more open-ended problem solving capability that relies on analytic thinking, not just memorization. "...I'll ask a question and the answer doesn't come up like it comes in a text book, almost verbatim for how you've asked the question," she says. "And they have to keep getting different information from the computer and try to figure out what the answer is, and I think it's a much higher level of skill that some of the kids use, and they like doing that."

Unfortunately, there are not too many software packages that meet the needs of the students she teaches, especially in trigonometry. But she firmly believes that if someone took physical manipulatives and put them into graphics, a lot of concepts could be taught in a way that took advantage of what the computer does well. As she realized from her work with simulations packages, the computer is uniquely suited to meet some very complicated instructional needs.

Marilyn is permanently assigned one computer with a large screen monitor which she uses as a demonstration device, but she generally manages to have two other computers with one printer in her classroom. These additional computers are on rolling carts and float among rooms in the math department. She sets these up so that students can use the computers for problem solving during class. After introducing math concepts she gives her students problems to review on the computer. While some students are using the computer, others work on individual or small group assignments.

Her class is located close to the lab, which allows Marilyn easier access than most teachers in her building. In addition, since some teachers have been moved to a different building because of declining enrollment, her scheduled use of the lab has increased. There are about 20-25 Apple IIes and Apple II+s with 12 printers in the lab. There are also 15 IBM PC Jrs that are distributed throughout the building. The IBM hardware was put into place as part of a special training project. The school provided the space and was permitted the use of the computers during the day.

Marilyn believes that if teachers have to go to the trouble of always going to the lab, computers will be used less often. She prefers the convenience of having machines in the classroom where they can be used whenever she needs them. In addition, because she does not always want or need to use the computer for

an entire lab period, she does not believe in tying up scarce resources needlessly.

Marilyn uses computers largely because they make mathematics lessons more interesting for her and her students. She thinks computers relieve some of the tedium of mathematics and they stimulate learning. Computers allow for a different kind of activity, and students tend to listen better to something that's new and different. For many students, though, computer learning is old hat; they come with some computer experience from elementary school and junior high and most have at least a small interest in computers and the knowledge that computers are going to be a big part of their lives. She makes an effort to get them to see what a computer can and cannot do in math, and at the same time tries to teach some good habits to students who will go into the more technical areas or possibly even programming.

At home, she uses her computer for activities related to her small business -- accounts, data processing, record keeping, and preparing tax forms. She also previews software at home before using it in her class and prepares tests. In addition, because of her interest in the theatre, her use outside of class has extended to giving occasional workshops for theatre management personnel.

Although Marilyn uses computers more extensively than other math teachers in her school, teachers from other departments in her school also use computers. The English department uses it extensively for word processing. The science department, which

participates in a project sponsored by the National Science Teachers' Association, recently has started to use Microcomputer-Based Labs (MBLs), hardware and software packages that allow teachers and students to attach a variety of probes to the computer, such as thermometers or motion and light meters, to collect data, to analyze these data in real time, and to present them graphically on the screen. These packages allow students to get a sense of what it is like to be a scientist in a lab. With the use of a temperature probe, for example, students can monitor temperature changes over time and see those changes graphed on the screen.

To summarize Marilyn's views on computer use, she sees the computer as a tool that makes possible activities that could not have been done before in the classroom. Simulations, for example, make it possible for students to explore scientific phenomena that may be too dangerous to do without the computer, or to demonstrate complicated concepts in probability. Graphing and problem-solving programs enable students to engage in high-level mathematical inquiry and to visualize solutions to complex mathematical problems.

TRAINING AND SUPPORT

Marilyn has attended many free in-service training sessions and has taken two courses at the local university, for which she paid and received graduate credit, but she has done a lot of reading, experimenting and evaluating software on her own. The

in-service training sponsored by her school system focused on programming and was offered in after-school sessions for 10-15 teachers, 90 minutes per week for eight weeks. Although she had already taken an introductory course in BASIC at the local university, she took a similar course offered by the school system because all her colleagues were taking it. This training was more than adequate for what she was doing at that time (using drill and practice software), because she felt that teachers did not have to know how to program, only how to boot up the computer. She recommends training "on a buddy system," that is, providing sessions for teachers from the same school and the same subject area in order to cut down the feeling of isolation. She considered group motivation a strength of her training--teachers had chosen to attend, nobody had twisted their arms, and therefore energy and interest were high. She says, "We were all mutually interested in computers in education...we really kind of fed off of one another."

Follow-up courses were taught by a former high school math teacher who shared many of his teaching experiences and his philosophy about using the computer to teach mathematical ideas and concepts. This training was especially useful as the emphasis was on integrating what was learned into the classroom, and participants shared"...projects that we'd really use in our classrooms...." She says, "The fact that we had a teacher who had really done that himself made it even better." Her only

complaint about the training was the frequency of equipment failures.

Parents in the district have insisted that computers play a role in their children's education. Two years ago, the city approved a bond issue in which a specific amount was designated to acquire computers for all the schools in the district. Support, however, uneven. She says, "The way it goes now, sometimes it's good and sometimes it's not, depending on what's happening in the politics of the district." But she adds that the district has supported good uses of the computer. The school administration is very supportive, as is the district computer coordinator.

The district office initiated a big push for computers five years ago but this has leveled off. There is currently no money for teachers to attend conferences or workshops outside the school district. Marilyn goes anyway, at her own cost; she believes conferences are an invaluable forum for keeping abreast of changes in educational technology and for continuing her own learning in mathematics education. The main difficulty is getting the time off to attend.. Most teachers don't go because conference costs can be as high as $500.00.

She is part of an informal network of computer users in the school, which includes teachers from both the math and science departments. She also is part of a network of math teachers in the district. These contacts give Marilyn an opportunity to share ideas with other teachers. This is especially important,

in her view, because the teacher is ultimately responsible for making sound but creative use of computers in the classroom.

Because Marilyn has been identified as someone whom other teachers may call on for help or advice, a lot of her free time is spent in this role. She says, "It´s almost a negative to know about computers because you get asked to do a lot of work for free."

There are no tangible rewards associated with knowing about and using computers in her school. The only rewards are personal: being recognized by her peers as an expert, and the satisfaction that is derived from seeing her students enjoy the computer, learning a subject that she loves--mathematics.

Marilyn would like to have professional time to develop uses of the computer in the classroom. She has lots of ideas, but needs time to sit down and organize them. Other teachers she feels, need time to figure out how to use the software in their classrooms; failing that, they need someone to screen software, then show them how to integrate it into their instruction. In addition, some teachers need help in resolving basic management issues--planning what to do with the rest of the class while a few students are at the one or two computers generally available. She is currently writing a proposal for a grant from a local school foundation to get funds so that each math class in her school would have a large screen monitor.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

The computer has subtly changed Marilyn's teaching style. She employs more of the discovery method and is less teacher centered. She is now able to give her students much of "what attracted her to mathematics in the first place." The idea of discovery learning is an ideal which did not always work in the past. She says, "I know that before computers were widely used, there were teachers who tried to get students to work in small groups--you know, the discovery approach and all that--and I think it has its place, but I think computers fit in very well with that type of process."

The computer enables students to work together. After she teaches a new concept to the whole class she divides the class into small groups so students can be more actively involved in testing their ideas. Before she had computers she demonstrated what she was teaching on the chalkboard; now, she presents a demonstration with the computer and lets students manipulate it.

She views the computer as a new teaching and learning tool and is comfortable with the idea that she does not know everything about it. Sometimes she has to admit to students that they might know more about computers than she does. She says, "When I first started teaching mathematics ...I felt pretty secure about what I was teaching, and I felt I could field questions in the classroom, and, except for an occasional word problem that might run amok, I generally felt the students could

rely on me to know what I was doing. I could go to the class confident of what I was doing. I now constantly run into situations where I'd have to answer, 'Well, let's go check that out,' or 'I really don't know.' At first that bothered me. Now I'm quite relaxed about it because there is so much to learn constantly, and it's quite common among my colleagues at other schools and for myself too, to hear teachers say, 'Well, I'm going to learn C this year along with my students. We're going to learn this thing together,' or 'maybe a student is going to bring in a piece of his or her software and show me what it does.' So I think students are now seeing teachers in general, much more as learners, and they see that teachers are learning all kinds of things and kids are often showing teachers those things."

One major impact on her curriculum is that Marilyn can cover more material, do more math, and reach a higher level of difficulty in the types of problems students can solve. She says, "Things that would be over the heads of the kids and would be saved for a college course in many cases can be done, very simply sometimes, with a computer." She finds that some problem-solving processes and strategies that are needed for some of the games cannot be done without the computer. Marilyn also likes the computer's ability to present material in a randomized fashion. She says, "The questions that pop up and the things they're asked to do are entirely randomized, so each time they

play the game it's different. There's no way that could be done with pencil and paper."

Marilyn also enjoys using a spreadsheet to solve equations, because she can instantly show the students the effects of their solutions, something she has been trying to get them to see in the abstract for many years. She says, "I teach graphing and equations now through a real discovery method...45 minutes later I can pose questions to them which they have all discovered about graphing equations, about slopes of a line, by playing and testing things out. The computer can do that right away. You know y=2x, y=3x. You see the line move up and down and they make generalizations. You can do that without a computer, but not as fast. So you can really cover more. It leads them to a discovery process in a 45 minute period, which you could not do without a computer." She believes that the quicker you can show students examples, the quicker they can get a better sense of what is happening, and the quicker they will learn.

Marilyn says that teachers have to be careful, however, not to invite the view that the computer is a magic box or a wizard that will solve everything, because some students have unrealistic expectations about what the computer can do, especially when they do not understand what operations the computer is carrying out. This is not unlike using the calculator, she says. When she began to use calculators in class, Marilyn found it necessary to think in terms of objectives and wrote behavioral objectives for calculator use--knowing how

to use certain keys, knowing how to do certain kinds of problems, knowing how to use memory, and so on. She thinks that computer use should be structured in similar behavioral terms.

Marilyn's use of computers has evolved over time; where before she was trying to make them fit into the curriculum, now she feels there's a place for them. All this has made teaching more exciting and challenging. She does not know how much effect it has had on her decision to continue teaching, but she does know that she is much more enthusiastic about teaching math. She remarked that, "All during the year I have to be learning new things...reading all the time...it's very exciting."

This is not to say that it has been easy. At first, using the computer made Marilyn's teaching more difficult, primarily because of all the preparation she needed to do. She says, "I don't ever think of it in terms of becoming easier. I just see more opportunities to try more creative things within my classes. ...Creating the tests and doing word processing, yes, that end of things certainly will be easier and more organized.... But in terms of the actual applications in the classroom setting, I don't see things becoming easier." In addition, while the science department has some leeway in developing the curriculum, the math curriculum is much more structured, leaving less free time for new computer-based activities. By the end of the academic year, students have to complete all the requirements for Algebra I so that they may advance to Algebra II.

Added to this is the problem of classroom management. According to Marilyn, "It's more difficult in the sense that you don't have all the nice control...that goes on in book learning." With computer learning, "...you have people roaming all over the place and (there are) lots of different levels of solutions." She finds however, that as time goes on, and as the teaching is better-planned, and the lessons carefully structured and organized, and as teachers know what they are doing and why they are doing it, teaching with the computer becomes easier.

Marilyn observes that computers are no longer a novelty, that students now take computers for granted. Nevertheless, they are as engaged in their math as ever before. In advanced classes, they appear more willing to engage in difficult, time-consuming thought processes. They are willing to stick with a problem a little longer. Even students who initially express reservations about computers seem, in the end, as engaged in the technology as others. She adds, "...kids just love it, not all the time, but they really learn and some of them can take the time to go over things as many times as they need to, to get it right.... They work and work, I mean, you have to drive them away.... If all teachers could feel what I feel in trying to keep people out of my room...."

She finds that boys are more eager to experiment with applications like graphics, while girls are better at "hanging in there with the process and learning the fine points of what you're trying to teach."

One consequence of computer use is that English and math teachers tend to talk to each other more than before, about things like grading utilities.

Because of her knowledge and expertise Marilyn has garnered "...a lot of respect." But she thinks this odd because one need not be especially talented or skilled to use a computer. The mystique is perpetuated by people who do not yet know how to use computers. Anyone who knows about computers is seen as an authority. She does not believe that teachers who have become computing experts will go off into other fields. These teachers see the computer as just another tool, something that helps them in their teaching, not as an excuse or reason to leave the profession. She says, "I think the reason for leaving teaching is not going to be computers or students. It's usually administrative or your class load or something like that....I really think they are a tool and an aid to teachers. It does take time, and a lot of effort, but it's rewarding...."

TEACHERS' INFLUENCE ON TECHNOLOGY

Marilyn is a member of a technology group of 5-6 people, including a representative from the elementary schools, another from the high school, the district computer coordinator, and the assistant superintendent. Together, they make the major decisions about computers for the school system. There is also a technology council comprising teachers that feeds ideas to the

technology group. This structure provides teachers with a more direct voice in the use of computers.

Marilyn thinks each student should have a computer and that computers should be integrated into the entire curriculum and utilized on a regular basis. If she ever designed software she would want it to be tied directly to the curriculum, to stimulate students to think and to solve problems. The software would also provide students with skills and information that they would need for making decisions.

As Marilyn sees it, computers allow the teacher to give students experiences that would not have been possible without them. In addition, it would be foolhardy not to use a tool with so many useful applications. Using computers, however, requires time, effort and organization. Having to run around to find computers and get them in the classroom was a problem Marilyn faced three or four years ago. Many times she was tempted to just throw up her hands and say, "Forget it! It's not worth doing it if I only need it for a short time and I have to see four teachers to get their permission to take their computers!" But, in staying with it, she has acquired important new skills for her teaching.

ALAN WHITE:

TRAINING AND SUPPORTING TEACHERS

'Alan White' portrays a computer teacher who divides his time between an inner-city elementary school and the district Office of Instructional Technology. As an elementary resource teacher, he has found that teachers who come to his lab find computers less intimidating and are more likely to use them in their classrooms. As a teacher trainer for the district, he helps teachers use computers as tools both in and out of the classroom. His approach is to make teachers comfortable with technology. He believes that successful training must have several ingredients: teachers must be able to take a computer home or use one at school; teachers should be able to select courses that suit their interests; teachers must be treated like professionals; and training must address practical needs of teachers.

INTRODUCTION

Alan White is a former fifth-grade math teacher who spends half his time as a computer resource teacher in an inner-city elementary school in the Midwest, and the other half as a special projects teacher in the school district's Office of Instructional Technology. Alan has thought a great deal about teachers and computers and cares deeply about the subject. A classroom teacher for eighteen years, Alan was asked in 1983 to join the Office of Instructional Technology to develop computer-related training courses for teachers in the district. He works closely with the subject area coordinators in the Office of Curriculum Services next door who are responsible for organizing inservice courses for teachers in their respective departments. Two years ago his former principal asked Alan to come back to the school at

half-time to help establish a computer laboratory. Alan has directed the lab on a part-time basis ever since.

Soon after he joined the Office of Instructional Technology Alan was invited to participate in the IBM Model Schools Project. Alan's district was one of 28 school systems that took part in the project. Alan and a colleague were sent to Bank Street College to be trained, and upon their return were given responsibility for training the 25 teachers in the district who were involved in the project.

COMPUTER USE

Alan's principal focus in the Office of Instructional Technology has been to help teachers use computers as tools both for work outside the classroom and for classroom instruction. This focus is in line with the current priority in the district, which is to use computers as "teacher productivity tools."

Originally, the district offered two very general computer literacy courses, one for elementary and one for secondary teachers. As more software became available, these two courses became more applications oriented. Teachers were shown how to use word processing programs, given some exposure to databases and spreadsheets, and provided with an opportunity to look at a variety of software that was available in their respective subject areas.

The district has now adopted a "cafeteria" approach to teacher training, offering a whole "menu" of one-credit courses,

each about five weeks in length, from which a teacher can select. Classes currently being offered include "Word Processing: a Tool for the Teacher," and "Database Management: a Tool for the Teacher." This modular approach to training has been extremely well received; teachers like being able to select only what is most useful to them.

For next year, Alan is designing a "software sampler" course in secondary language arts. Teachers will evaluate software for five weeks and choose a package that fits their curriculum. The final project will be to create a lesson plan that integrates the program into a regular lesson. The lesson plans will be shared among all the teachers in the course; as a result, teachers will be able to take from the class a number of classroom applications that they can use with their students.

Alan points out that most of the teachers who have become computer experts come from areas like mathematics or media services; they tend not to be elementary teachers who have to teach all day long. "You almost have to be outside a classroom setting to have the time to explore it to get to any type of expert status with it," he says.

TRAINING AND SUPPORT

Alan has learned that it makes little sense to train teachers when they have no access to the hardware and software used in the training. "You just build up the frustration and the already present cynicism in teachers," he warns. From the IBM

project Alan and his colleagues learned how important it is for every teacher who goes through training to have an opportunity to take a machine home for a few weeks, or at least to use one freely at school. For one thing, they get a chance to practice and explore on their own. For another, giving teachers a computer lets them "know that we care," Alan says. More importantly, teachers "will come to school with twenty more ideas" than they had before they took the computers home.

What also makes for good training, according to Alan, is to provide teachers access to computers without any expectation that they will use them in their teaching. The approach Alan takes is to help teachers become comfortable with the technology. He shows them, for example, how to do on the computer some of the things they would routinely do on the typewriter, such as writing a quiz. If teachers are not expected to use computers immediately in their teaching, and if they are shown how technology can make some aspects of their job easier, Alan asserts, they will become interested in what can be done with computers no matter how scared or uninterested they may have been at the beginning.

Third, training is most successful when teachers volunteer. Alan says that teachers learn best when they select courses that interest them and come to class without coercion.

Finally, and perhaps most importantly, Alan believes, teachers need to be treated like professionals. According to Alan, this means paying them for their time as well as providing

some kind of credit, either for recertification or toward a degree. In this way "teachers get two payoffs, besides learning something new." By providing reimbursement and credit, Alan says, school administrators show that they view the training as important. Although money is rarely the most important motivator for teachers, paying them for their time is one way that schools can show teachers they are valued.

One of Alan's principal tasks, is to help colleagues overcome their fear of computers. Some are simply afraid of the technology, he says, afraid of breaking the machine or looking incompetent. Others are curious but have been put off by a frustrating training experience. Still others are less anxious about computers than they are reluctant to learn new ways of teaching. This latter response is particularly prevalent among older teachers, Alan reports. They seem to be saying, "I'll be gone in a couple of years; there's no point learning something new." Such teachers take the required training, but do so only half-heartedly.

Alan perceives a marked generational difference among teachers. "The new teachers that have come on to our staff are more willing to explore with the computer, they already have word processed themselves ... so they don't seem to have this computer anxiety that teachers who have taught a while have. [The younger] teachers do not necessarily know good ways to use the computers with kids ... but at least most of them know how to use a computer themselves."

Alan defines computer anxiety as "a real frustration which occurs when you're not able to proceed with a project because you don't know which key to press or which button to use. And if someone can't tell you that, you just have to stop your project. This machine won't let you go any further; even though you know what you want to do, you don't know how to make this machine do it for you. And I think there's a certain intimidation that this machine can have that power over you.... You feel like you're not very smart."

Another contributor to teachers' anxiety, Alan says, is that in the beginning "there was so much adoration of this machine." Teachers thought, "my god, what is this going to do to me?"

Alan believes the way to reduce the "technical mystique" that surrounds computers is to show teachers how computers can be integrated into the traditional curriculum. Teachers must be convinced that computers are not just another burden that is imposed on them, but that computers can help them "teach some things better."

During the fall, Alan spends about three to six hours with each class in his elementary school, focusing on an area of the curriculum the teacher wants to explore, and getting students used to working with computers. In approximately December he begins his Geometry Project, where he works intensively with seven teachers. He also works closely with two other teachers on word processing activities. As a consequence, during the latter

part of the school year he is less available to the rest of the teachers.

As a resource teacher, Alan has focused on integrating computers into the curriculum and has emphasized the connections between teachers' classroom instruction and what goes on in the computer lab. He has used Logo Writer for the last two years to develop geometric thinking skills in children, and to help children with their creative writing. Alan's lab has 15 Apple IIe's with 4 printers and a large monitor; an additional 10-15 Apple computers rotate among the classrooms. He agreed to be the computer lab teacher on condition that he be allowed "to do something beyond drill and practice." Because other teachers were already familiar with drill and practice software, Alan wanted "to take kids into some other uses of the computer."

He typically works with a whole class, about 30 students at a time, who work in pairs on the 15 computers. Alan takes about 15 or 20 minutes at the start of a lab session to introduce a new concept or technique, and then gives the children about 35-40 minutes to work on their own.

In contrast to what happens in most other schools, Alan has succeeded in bringing teachers into the lab. The catalyst was a special project that was aimed at raising the geometry scores of lower achieving students. The principal insisted that teachers be present while Alan taught the lab. Some teachers took advantage of being there to learn word processing or Logo. Others helped Alan attend to students' needs and questions as

they worked on the computers. In one instance, he and another teacher team-taught some lab sessions on word processing.

Alan has found that bringing teachers into the lab makes computers less mysterious and intimidating. It helps teachers overcome their anxiety about computers, "because if something happens, I'm right there to say, 'No, you just press this button,' and on they go instead of becoming frustrated and giving up on it. And I think they also see how well their kids take to it." The lab has also been an effective way to get teachers to use computers in their classrooms. Alan thinks "that's the result of having the time to talk a little bit" about instructional objectives and about available software. Alan invites teachers to bring their classes to the lab and offers to show them how to use a particular program and how to tie it into the curriculum. He also makes it clear that they will not be held responsible for getting students started on the machine, that he will do the training. "The blending of our expertise, my having the technology knowledge, and coming from the classroom setting where I still appreciate their teaching problems ... is one of the secrets that has increased my success," Alan says. He has found that this approach also works with teachers who "are not computer anxious": Alan shows them how to use the hardware and software and how to manage classroom instruction.

Alan places much of the credit for the success of the computer program in his school on the principal. "I've had extraordinary support from my principal," he says. "I have the

equipment I need, a teaching schedule I can cope with, and a lot of support for the curriculum I want to develop and the way I want to work with students and teachers.... I have a lot of instructional freedom in what I do. I'm following district guidelines and meeting district objectives, but I really feel I'm teaching in a way that I'm very comfortable with, and the principal supports that." The principal has earmarked more money for computers than principals in other elementary schools in the city, according to Alan.

The computer program in Alan's school also enjoys the strong support of the local community. The PTA, before whom he has appeared many times to talk about computers, has contributed about $2,000 to the computer program, which the school has used to buy a color printer, software, and blank disks. In addition, a business community grant has provided the money for five computers and a printer for a special word processing project.

Once teachers complete their training they need to know there is someone in the system they can turn to. The lack of adequate building-level support staff in Alan's district, however, has made the phone an extremely important vehicle for helping teachers. But support by phone is not sufficient. According to Alan, the ideal solution would be to have a cadre of resource people within each school building to answer questions and solve technical problems, rather than have central office staff provide help by phone. Teachers often need help right away and are not served well when they are put on hold or have to

leave a message. To fill some of the need for building-level assistance, the district has hired several area computer resource people, each of whom is responsible for a portion of the schools in the district. Some principals who view this support role as an important ingredient in the success of their computer program have asked the media aides in their buildings to serve as computer resource consultants to teachers.

The district has also organized a computer lab which is open two evening a week. Teachers come to get help with a problem or to ask questions; teachers can also use the lab to preview software and to plan classroom activities. Alan or someone else is always available during these evenings to help teachers. Half the questions deal with classroom uses of computers and the other half have to do with personal uses (some teachers, for example, are using word processors to write dissertations). Alan encourages questions related to personal use because he finds teachers' interest quickly spills over into other areas.

In addition, Alan and others in the Technology Office are trying to build networks among teachers who are using computers in their teaching. Some of the buildings are extremely big, Alan points out. A teacher in the foreign language area may not know that there's a social studies teacher way down in the other end of the building who's using a computer and could probably answer questions.

Despite all these supports, teachers continue to find some aspects of teaching with computers difficult. "There's a real

problem of how to handle new software." Alan says. Teachers would like to know what software is available in the district and how it could address their objectives. Alan, too, needs this information so he can help other teachers. Most teachers have little time to search for software they can use in the classroom. This is a particularly thorny problem for the elementary teacher who has little or no time during the day to preview software.

EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

Alan believes computers have changed how he teaches. They "have really helped me open up my teaching in terms of kids teaching each other more.... the computer has really helped me move into being more of a facilitator of learning rather than a lecturer.... I'm letting children discover more things on their own, working together more, I think I'm teaching more in a problem solving way than I did before," Alan says.

He is gratified that some of what he does in the lab seems to be rubbing off on other teachers. Although most math teachers like a very quiet classroom, those who come to the lab with their students "do not seem to object to the amount of conversation that I allow in the computer room," he says. As a result of "the subtlety of having the teacher come along," and "without consciously encouraging" them, he's "getting teachers to open up a little bit, at least in the teaching of geometry." Teachers are better able to tolerate a lively discussion and team problem solving in their classrooms.

But for the most part, the teachers Alan has worked with have not dramatically changed their teaching style. "They're still teaching the same things in basically the same ways that they have been teaching, and then on the side they're sticking computers in," he says. "It has not made a good teacher any better; it hasn't made a bad teacher a good teacher."

Nor does Alan see much impact on the curriculum. Computers have had an effect "up to the point that we know we have to revise our curriculum.... We might be able to expose children to some very high level mathematical concepts, that in the traditional paper and pencil textbook mode they would not be able to deal with until a later age. I think there are some concepts that we can now teach children earlier and teach to them in a meaningful way, because the computer can do some things for them, like drawing coordinate points, that they might not have the computational skill to do right now. It's something like the calculator." But by and large, the computer's effect on the curriculum remains an unfulfilled promise.

He thinks computers make teaching more difficult, particularly at the beginning. "It provides the teacher a greater opportunity to individualize, [but] just because you have that capacity does not make it easy; as a matter of fact it makes it harder," he says. Managing a classroom and assessing what students are doing on the computers make the instructional process more difficult for teachers. "Individualization is a very difficult thing to manage," he says. "It took me two months

to understand what's going on, then it took me a year to learn all the programs and all the intimate details and intricacies of how that room worked. It took me a good year to get comfortable."

Alan believes that for students whose families don't have the means to buy a computer, schools fill an important gap, providing exposure to computers at an early age, and giving poor children opportunities to obtain skills that will be useful in school and later in the job market. Eighty-five percent of the students in Alan's school come from poor families and receive subsidized or free lunches. He views technology as "something that is going to open up their futures a bit more, in spite of some of their deprivations." Alan, however, is very concerned that many principals and teachers find it appropriate to have good students use computers for enrichment, problem solving, and programming, while low achieving students use computers primarily for remediation and drill and practice.

As a teacher of lower achieving students, Alan has seen how effective computers can be not only in motivating children, but also in helping them gain a deeper understanding of difficult concepts. He believes computers have three major advantages over traditional mediums of instruction. First, the computer's graphical or pictorial capabilities help make abstract ideas more concrete. Second, some uses of the computer require students to construct or to manipulate things -- to write a program or to run a simulation. In Logo, for example, "you have to really know

what you're doing in order to get the turtle to be successful. You don't just have to know the Logo language. You have to know the concept, and you have to be able to recreate that concept." Third, computer use facilitates the sharing of ideas and group problem solving among students; "pairing kids [at the computer] is better than letting kids work alone," Alan believes, "because they talk to each other a lot."

Alan argues, however, that in order to benefit from the use of computers, most students he works with need some direction. It is inefficient "to just let children play around at the computer.... I think you can guarantee that children are going to see ... important mathematical ideas ... more easily if you structure some lessons towards specific objectives." Alan prefers to err on the side of "over guiding students" because he has taught "many students who can get nowhere unless instruction is broken down into small, sequential steps for them."

DISCUSSION

The composite profiles included in this report convey the diversity and patterns we found among the teachers we interviewed regarding the conditions and effects of their uses of new technologies. The composites portray rich and textured examples of teachers' experiences. This section aims to complement these profiles by summarizing patterns that emerged across the entire set of teachers and discussing these results in light of related research. We have organized this section around the following topics: how teachers use computers; influences on teachers' decisions about teaching with technology; the effects of new technologies on teachers; and the resources and supports that teachers want.

HOW TEACHERS USE COMPUTERS

The most common use teachers in our sample made of computers was outside of their classrooms. The majority made some use of computers either for professional or personal purposes at home, at school, or in connection with other activities, such as coaching athletic teams or volunteer work. Many teachers found word processors, data bases, and other application software, such as grading packages, to be a great help in preparing lessons and teaching materials, and keeping records of student work.

Within the classroom we distinguished two general ways of using computers: (1) as a tool for teaching and learning subject

matter in the regular curriculum, and (2) as an object of study. Within the first category, computers supported a range of activities including data analysis and problem solving, drill and practice in academic skills, and word processing for course-related work. The second category of use included programming and learning about computers, for example in computer literacy courses not connected to students' work in their regular academic program. More of the teachers we interviewed used computers in the first way, as an educational tool within the regular school curriculum. Further, we found teachers at least as likely to use the computer to support students in open-ended problem solving activities as for drill and practice. This pattern of response is different from results reported by Reed (1986) based on a recent survey of teachers who favored using computers to teach computer awareness and literacy. It also differs from Henry Becker's (1986) most recent survey, but is consistent with the overall trends he has identified in teachers' uses of computers. The survey he conducted in 1985 indicated that the majority of elementary teachers still found CAI the best use of computers and that the majority of secondary teachers found programming and computer literacy the best use. At the same time, he noted that as teachers become more experienced in using technology they tend to shift from these kinds of uses toward viewing the computer as a tool to support the regular school curriculum. Overall, his 1985 survey indicated a movement in this direction when compared with his 1983 survey data.

We surmise that our findings are consistent with the progression that Becker has identified toward using the computer throughout the curriculum and using it more to support open-ended problem solving than drill and practice on tasks with one right answer. This conclusion is supported by comparing our interviewees' opinions about how they thought computers ought to be used with descriptions of how they currently did use computers. More teachers in our study thought computers ought to be used as a tool for teaching and learning throughout the curriculum than actually did use computers in this way. Also more teachers thought the computer ought to be used to support inquiry learning (to "take emphasis off algorithmic learning and allow the teacher to develop concepts", as one teacher said) rather than for drill and practice.

INFLUENCES ON TEACHERS' DECISIONS ABOUT TEACHING WITH TECHNOLOGY

Three general kinds of factors were seen to influence teachers' decisions regarding the use of technology in their classrooms. These are teachers' beliefs about the educational potential of computers, external pressures and opportunities, and access to resources and support. Untangling these factors to explain any single teacher's decisions would be difficult, but recognizing the nature of their influence indicates points of leverage for those who wish to change teachers' minds and behaviors.

Teachers' Beliefs

Teachers' expectations and attitudes about the potential benefits of any innovation strongly influence their inclination to adopt it (Mohlman et al., 1982). Teachers we surveyed frequently mentioned two rationales for using computers in their classrooms: (1) computers will be increasingly important in the world so students ought to know about them, and (2) computers equipped with appropriate software can improve teaching and learning. Teachers with more experience using computers in their classroom seemed more likely to be motivated by the educational potential of computers than by a desire to prepare students for a technological future. As one teacher said, "I wanted to be part of the 'wave of the future' and got a computer at home, but now I'm more impressed by its impact on teaching and learning." A third motivation mentioned frequently, but less often than the first two, was the teacher's own interests, such as a fascination with computers, a desire to motivate students, or a wish to save time preparing materials. In summary, it seems likely that an interest in the technology itself might draw teachers into using computers, but that subsequent personal or educational payoff would be necessary to sustain their interest.

Teachers' beliefs can also make them disinclined to work with new technologies. The most frequently mentioned barrier was a belief that computers would not make a sufficient contribution to teaching and learning of the subjects they taught to outweigh the costs involved. Several teachers expressed concerns

either that the computer would undermine their students' learning or that no software they knew of could significantly improve education in their area. Others had seen interesting uses of computers, but felt they could not introduce any new activities into their courses and still "cover the required curriculum." Some teachers expressed fears about the technology itself. They worried that it was too complicated, likely to make students into automatons, or to encourage teachers to take unfair advantage of "electronic babysitters". The latter kind of reservations seem amenable to change in the face of persuasive arguments about educational potential. Several teachers interviewed said they had overcome their fears once they saw something truly worth doing with computers in the classroom.

External Mandates and Special Opportunities

External policies, district priorities (Amaral, 1983; Jackson and Deal, 1985; Rogers, et al., 1985), and opportunities created by special programs exert a major influence on teachers' uses of technology. These external forces include overall school system norms and values (e.g., a tendency to track students by achievement level or to emphasize teaching students to become proficient problem solvers), as well as policies dealing specifically with educational technology. In the sites we studied, the latter included mandates passed by local school boards or state legislatures, building level priorities set by principals, particularly powerful "visions of possibilities"

presented by colleagues or trainers, and pressure from parents or students. Every site in our study was subject to one or more state or local policies regarding the uses of computers in the schools. Several sites operated under a requirement (generated either by the local district or the state) that students be taught computer literacy. A few had recognized that such mandates tended to isolate technological resources from mainstream education and had attempted to remedy this situation. In Washington, D.C., for instance, a five-year-plan has recently been adopted to promote use of computers within the regular curriculum. The plan includes both incentives -- hardware, software, and training opportunities -- as well as requirements -- a course on educational technology will become a prerequisite for teacher certification. This emphasis on integrating computers into the traditional curriculum is consistent with the trend in many state departments of education (Electronic Learning, October, 1987). Whether computer-related mandates and pressures encourage truly educational uses of new technologies is debatable, but that they exert a powerful influence on teachers' decisions is clear.

Access To Resources and Support

The third major category of factors influencing teachers' decisions about educational technology concerns access to resources and support. Necessary resources include software, hardware, "mindware" -- meaning knowledge and skills, and

courseware -- teaching and learning materials (Becker, 1985; Linn and Fisher, 1984; Sturdivant, 1983; Tetenbaum and Mulkeen, 1984.) Clearly, in order to be truly useful, resources must be synchronized so that teachers have access to a useful combination of ingredients. Access to hardware without appropriate software or training is as useless as training without subsequent access to the technology. Teachers we interviewed mentioned the software and hardware most often. Teachers who cited software as a significant barrier noted a host of problems from not knowing what was available, to finding that available software was inappropriate, to struggling with a single disk when what they needed were multiple disks. On the matter of hardware, teachers emphasized that the mere presence of computers in the school does not guarantee sufficiently convenient access. The location of the computers as well as the process for scheduling their use shapes whether and how teachers might use the hardware. A single computer in the classroom may serve effectively as a learning station for small groups of students in rotation; equipped with a large monitor, the same computer can also serve as an "electronic chalkboard" to enrich interactive demonstration lessons. A laboratory of computers is suited to other uses. It enables a lesson in which the entire class is engaged in computer-based activities at once, but this potential is lost if the lab is too remote from the regular class or too difficult to schedule. For teachers who want to use computers in the former way, the latter arrangement of hardware is useless.

Many teachers in our study noted that special programs with technology components, such as computer literacy courses or Chapter I classes, had priority or even exclusive access to the computer lab. As one teacher said, "There's a lot of talent in the system that's being wasted because the computers have been put under the lock and key of one person."

The other most frequently mentioned barrier to using educational technology was a lack of access to appropriate training. Nearly all teachers had access to some form of training with computers, but several conditions made training fall short of sufficiency. The most frequent complaints were that the training did not prepare teachers to integrate the computer into their teaching, that it did not include enough time for them to become comfortable with the software, that it did not include follow-up support to help them "troubleshoot" during the early implementation stages, and that the training experience was not tailored to the teachers' needs.

Few teachers specifically mentioned the lack of courseware as an important impediment, but the issue is implied by those who said they did not know how to integrate the technology into their courses. A few more experienced teachers in our study confirmed what other research (Cline et al, 1986; Hawkins and Sheingold, 1986) has shown, namely that the "orchestration" of integrating new technologies into the traditional curriculum is not simple. Teachers need lesson plans, teaching aids, problem sets and worksheets in order to carry out lessons with computer

technology. To invent and produce such materials is very time-consuming and may preclude computer use, even when all other implementation requirements are met.

EFFECTS OF NEW TECHNOLOGIES ON TEACHERS

When asked about the impact of introducing computer technology into their classrooms, teachers mentioned a range of effects including changes in the content and sequence of their curriculum, changes in students' roles, and changes in their own behavior as teachers. Because we were collecting teachers' opinions, we have chosen to focus this discussion on their remarks about impacts on themselves: their teaching style, classroom management, and roles.

In asking about the effects of new technologies on teachers, it is important to recall the image of a computer as a Rorschach card (Amaral, 1983), onto which educators can project a myriad of purposes. The range of possible software allows the computer to serve as an educational tool for virtually any subject matter, any educational philosophy, any teaching approach. Even a single piece of software may be suitable to a range of educational purposes, serving as a provocative learning station for single students in one case, a tool for interactive demonstrations led by the teacher for the whole class in another case, and the focus of collaborative problem solving for a small group of students in yet a third case.

With this variety in mind, asking, "What effects do

computers have on teachers?" seems as broad as asking, "What effects do books have on teachers?" Obviously, teachers' perceptions about the impact of computers in their classrooms will depend on their instructional goals, their accustomed teaching approach, and the kinds of software they have used. While our study did not permit systematic analysis of the relationships among these variables, it did reveal patterns in teachers' perceptions about the impact of computers in their classrooms. We regard their perceptions as important pointers toward areas that merit further study.

Teaching Style

Of the teachers we interviewed who had taught with computers, the majority mentioned that computers had helped them vary the traditional picture of the teacher lecturing the whole class of students. "I used to throw information at people and expect them to memorize," said one teacher who thought she had changed her style. Computer technology facilitated an approach in which students work on problems individually or in small groups while the teacher circulates among them, setting the stage perhaps for another sort of lesson in which the teacher helps the class synthesize their findings according to the teacher's curricular goals. Teachers report that computers present a medium which students can manipulate either individually or in small groups, and which engages students more actively in learning and thinking than most lecture-oriented lessons.

Students are able to work at their own speed and to figure out more for themselves. Teachers can function more as facilitators of students' learning than as presenters of ready-made knowledge. "I've become more of an involved participant than an authority figure ... a learner with students rather than a presenter of facts," said one teacher.

Teachers who use computers to facilitate this kind of lesson often report that they have seen encouraging shifts in students' roles. Students take more responsibility for their own learning and tend more often to help each other learn, working together to solve problems. Some students who do not respond well to lecture-type lessons deal more positively with the interactive, visual medium of the computer. Thus the introduction of computers may create new opportunities for learning and leadership in the classroom. These kinds of perceptions are very consistent with the findings of Hawkins and Sheingold (1986) who reported that the introduction of Logo in classrooms seemed to promote a "restructuring of expertise", including an increase in "peer expertise" recognized by students.

Some teachers (Hawkins and Sheingold, 1986) note that by circulating among their students while they work at the computer, they notice more about the way their students are learning. As one teacher in our study said, "I learned a lot more about the individual learning needs of my students because I can watch them learn. Previously when I was in the teacher-centered model I

really couldn't watch them learn as I was busy delivering the curriculum, so my role has changed that way ... being able to learn a lot more about my students because of computers."

Amidst these enthusiastic reports of significant positive effects on teaching style, we also heard from many teachers who thought computers had exerted little or no influence on their classroom behavior. These reports tended to stem from two quite different circumstances. Teachers who used drill and practice or tutorial software usually found that the computer had had no effect on their teaching. This software is designed to be used by individual students working independently from the teacher. Because computers used in this way require little involvement from teachers, it is not surprising that teachers find computers have little impact on their pedagogical approach.

The other reports of "little effect" tended to come from teachers who reported that they had always been committed to tailoring lessons for individual students or to "discovery learning" approaches. For many of these teachers computers seemed like a natural extension of their arsenal of teaching tools, "a vehicle that fits into the way I was already moving." Another teacher echoed the sentiments of several in saying, "Computers fit in with the discovery approach." He customarily presented concepts to the whole class and then broke the class into small groups to become actively involved in solving problems. Other teachers who were used to setting up several

learning stations or activity centers in their classrooms found that the computer became just another, interesting station.

Very often the new tool is adapted to the teachers' existing style (Berman and McLaughlin, 1974; Hawkins, 1985; Jackson, 1986). As one computer trainer said of teachers in her district, "They're still teaching the same things in basically the same ways that they have been teaching, and then on the side they're sticking computers in." This finding is not surprising in light of the stability of the curriculum and social organization of schools (Cohen, forthcoming; Goodlad, 1984; Sarason, 1971) and the relative unimportance of technology in comparison with human judgment in the overall craft of teaching (Heinich, 1985; House, 1979). What is more surprising, and worthy of further attention, is the extent to which teachers report that teaching with computer technology has significantly affected their practice. We need to understand more about the circumstances surrounding such reports.

Classroom Management

Among teachers who have taught with computers, there is nearly unanimous consensus that, at least initially, most uses of computers make teaching more difficult. It takes planning to incorporate computers into a lesson, to sort out the logistics of who will use computers when and where, to make sure the necessary equipment and materials will be available, to design a fall-back lesson in case the technology malfunctions. Assessing student

progress may be more difficult when students are tackling more open-ended sorts of problems, collaborating with other students, and turning in assignments that require more than a right/wrong grade (Hawkins and Sheingold, 1986). Although computers may facilitate the process of tailoring learning experiences to individual students' needs, the process is still difficult. As one teacher said, "It took me a while to get used to all this. It took me two months to understand what was going on...then a year to get good at it...to learn all the software programs and all the intimate details and intricacies of how the room worked....It took me a good year to be comfortable...but by the end of that time my room was pretty red-hot." Another teacher vividly conveyed the experience of working with students in the computer laboratory, "Days I spend in the lab I wear tennis shoes."

While teaching with computers may initially require more preparation, teachers also report that the technology eventually eases some aspects of classroom management. Students often find their work on the computer interesting so that teachers find they encounter fewer discipline problems. A few teachers reported that they use spreadsheets or special purpose grading programs to help with record keeping and a great many of them said that applications software like word processors and database managers have streamlined their work in preparing lessons and keeping records.

Effects On Teachers' Roles

A large number of teachers found that their experience with computers added new informal dimensions to their role outside the classroom (we discussed changes in teachers' roles inside the classroom earlier in the section about impact on teaching style). They often serve as resident experts in their building providing advice, encouragement, and assistance to their colleagues as they begin to use computers. These teachers may also become trainers. Most teachers who had experienced such shifts in role said they enjoyed the admiration they received and were pleased to serve as advisors to their colleagues. Only a few of the teachers in our study complained of the extra work.

For some teachers these role transitions were accompanied by a formal change in position. A common progression reported by teachers in our study was from subject matter teacher to computer literacy teacher (or to a combination of these roles), to computer coordinator, or to trainer serving teachers in one or more schools. Some teachers reported that their expertise with educational technology protected them from falling victim to budget cuts. They were able to move into new teaching or administrative positions requiring familiarity with computers when their former positions were eliminated by budget reductions.

Hardly any of the teachers in our sample thought new educational technologies would be the deciding factor in teachers' decisions to stay or leave the profession. Many acknowledged that using new technologies had refreshed them

professionally, making teaching more interesting. And others acknowledged that computer expertise could enhance their marketability outside the school. But most insisted that decisions about whether to leave the profession are primarily influenced by salary, perceived status, and feeling appreciated.

RESOURCES AND SUPPORT THAT TEACHERS WANT

Given that our study was based on a single interview with each respondent, it does not give a clear picture of the evolution of teachers' desires over time. Nevertheless, the pattern of responses suggested that the teachers we studied experienced a progression of concerns comparable to those described by other researchers (Hall, 1979; Loucks and Hall, 1977); Wedman et al., 1984). Loucks and Hall have described a typical progression in teachers' concerns and their ways of viewing a new teaching approach. Initially teachers focus on the mechanics of the innovation and on its impact on their own lives. As they become more comfortable carrying out the new approach, it becomes more routine and less visible, and teachers focus more on its effects on their students. If they see positive effects, teachers may progress to an interest in expanding the innovation and encouraging others to try it. In keeping with this pattern, teachers with very little experience of computers often want a gentle introduction paced to prevent their feeling overwhelmed by the machinery. In contrast, teachers who have come to grips with these issues may want support from an advisor in their classroom

who can help demonstrate effective management techniques and consult about ways of organizing lessons. Still other teachers may not want advice as much as they want easy access to hardware to reduce the logistical burden of teaching in a way they know perfectly well how to do. This variation clearly suggests that teachers needs must be assessed before they can be satisfactorily met (Winkler, 1985; Winner, 1983).

Hardware and Software

With this warning duly noted, it is still informative to review the kinds of resources that teachers in our study desired. Access to hardware and software were mentioned frequently. Many teachers emphasized that location and schedule of access to hardware are very important. Access both in the classroom (one to four computers with one large monitor) and in the laboratory was described as the ideal arrangement. Given that many of the teachers in our study wanted to use the computer as a tool for teaching and learning in the subject areas, it is not surprising that many of them saw particular need for hardware in their classrooms. Other studies (Reed, 1986) suggest that teachers who think computers should be used to teach computer literacy as a separate course favor placing computers in laboratories.

Enticing Visions of Teaching With Technology

While teachers report that the quality of software is improving, many still lack clear visions of how to teach

effectively with technology, how to organize their classes, how to weave the technology-based component into the rest of the course. Seeing experienced teachers in action is helpful as are opportunities to talk with colleagues. Many of the most extensive users of computers participated in a supportive network of colleagues (either in their school or district) who stimulated new ideas, offered recommendations about problems, and celebrated accomplishments. Several of the more experienced users of new technologies remarked that reluctant teachers need to be shown clearly one way of using computers, either to alleviate their work outside class or to enhance some part of their classroom work. The veterans suggest that once new users become accustomed to one approach and see its value, they will gradually branch out to other uses of the technology.

Effective Training and Follow-up Assistance

Teachers in our study mentioned several features of effective training which are consistent with other research on staff development. They emphasized the value of training with plenty of "hands-on" time to experiment with hardware and software that they could use in their classrooms (Cline et al., 1986; Sheingold, Martin & Endreweit, 1985; Watt and Watt, 1986). They wanted follow-up assistance from advisors (Zigarmi, 1978; McDonald and Naso, 1986) who could not only answer questions about the technology, but also help them figure out how to incorporate the new approach into their curriculum and regular

teaching activities (Doyle and Ponder, 1978; Stecher and Solorzano, 1987). Teachers noted the value of informal exchanges with colleagues engaged in similar innovations, echoing findings of previous research (Watt and Watt, 1986; Wiske, 1986).

Layers Of Support

Teachers who seemed most satisfied with their uses of educational technology were often the beneficiaries of several layers of support. This finding is consistent with a great deal of research (Jackson and Deal, 1985; Loucks et al., 1982a; Meister, 1984) which clarifies the nature and necessity of support from administrators and colleagues to sustain innovation. These layers of support include:

- on-site aides to assist with logistics, e.g., lab aides who help set up equipment and arrange for maintenance
- a district computer coordinator to organize systems for reviewing and purchasing hardware and software and to serve as a computer "champion" (Rogers et al., 1985)
- colleagues with whom to exchange strategies and build an atmosphere that supports collegiality and experimentations (Little, 1982; Parker, 1971)
- building principal to provide incentives like time, money, and moral support (Farrar, 1987)
- district-level support for developing clear priorities around educational technology and assuring the allocation of resources to address these priorities (Sturdivant, 1983).

Clearly, particularly able and enterprising teachers can manage without some of these resources.. But the majority of

teachers need considerable assistance and encouragement to learn how to incorporate computer technology into their classrooms.

More Influence On Educational Technology Policy and Design

Besides these kinds of direct support for their work in classrooms, the teachers we studied also wanted to exert more influence over decisions about educational technology. Specifically, they regularly reported that decisions in their schools were not sufficiently informed by teachers' priorities and constraints. The same claim held true even more often at the district level and other more remote levels of the educational administrative system. While some teachers did not personally want to participate in advising decision makers, many thought teachers' voices needed to be better taken into account.

Another area in which teachers wish to exert more influence is software design. Although relatively few teachers described software they themselves would like to design, many thought that educational software could be improved if it were developed in consultation with teachers. This recommendation echoes that made by several researchers (Char and Hawkins, 1987; Hawkins and Kurland, 1987) who have investigated software development and implementation.

Research

One final desire expressed by several teachers in our study was research on the effects of computers on teaching and

learning. Teachers recognized that their hunches about the impacts of computer-based approaches did not by themselves provide a firm basis for making further commitments and decisions regarding educational technology. The growing body of research on this topic (Chen, 1985; Hawkins and Sheingold, 1986; Jackson and Deal, 1985; Pea and Sheingold, 1987; Winker et al., 1985; Yin and White, 1984) recommends that effects be studied in conjunction with investigations into the implementation process. Such studies may reveal relationships between patterns of use and effects and may illuminate changes in the use of educational technologies over time. Many computer-based educational innovations aim to achieve goals not readily measured by standardized achievement tests. Thus standard teaching experiments focused solely on traditional outcome measures are likely to overlook important effects resulting from the introduction of new technologies into the classroom. Several teachers in our study appeared to endorse the recommendation of researchers (Hawkins and Sheingold, 1986) who favor observational studies of classrooms to clarify the elements of classroom life where effects might likely be discerned, including changes in the content and sequence of the curriculum; changes in student and teacher beliefs, attitudes, and behaviors; and redistribution of authority and responsibilities in the classroom.

POLICY CONSIDERATIONS

These policy considerations are drawn from needs and desires identified by teachers in the study interviews and are informed by the literature and the experiences of the study team members.

PERSPECTIVES

Being Clear about What We Mean by "Computers in Education"

A primary consideration in the development of policy is to distinguish among the ways and contexts in which computers can be useful in education. These include:

Computer Science (a subset of mathematics as a discipline)
Computer Literacy (general knowledge for the general population)
Computer as a management and administrative tool for teachers
Computer as an instructional tool

Each of these is a legitimate educational application of technology, but each has unique requirements and payoffs. In thinking about meeting needs, stimulating activity, or allocating resources, it is important to be clear about the objectives and which use is the appropriate target. In this study, our attention has been focused primarily on the target of the computer as an instructional tool.

Computer As An Instructional Tool

We focus here on the computer as an instructional tool, using the computer for the teaching and learning of subject matter and content for a number of reasons. In our interviews

with teachers, this is the use of computers that most teachers addressed and about which they voiced concerns. As reported by teachers, integrating the computer into the curriculum is a common objective and a complex undertaking and one where training and support are needed. In addition to representing accurately the views of those we surveyed, we believe that at the elementary and secondary levels, the use of the computer as an instructional tool provides the greatest potential for engaging the largest number of teachers and for affecting student learning most broadly.

The vision expressed by teachers is that the computer can have a significant effect on the content, skills, scope and sequence of the curriculum, and on the process of teaching and learning. Teachers who have been using technology extensively, as well as those who expect to use technology in their teaching, are interested in the potential of technology to support learning that is more open-ended than drill and practice. The vision is provocative and engaging for many, but a reality for only a few.

Integrating The Computer into Instruction: A Systems Approach

From the interviews and from our own experience, we know that integrating computers into the curriculum is no small effort. No one questions that the use of computers in education requires hardware. But what may not be as apparent is that the use of computers as instructional tools, like the successful

application of any significant technology, requires that an integrated system of resources be in place.

From the interview data, we can define the system requirements for using computers successfully as instructional tools. There must be: adequate hardware, appropriate software, related courseware, a knowledgeable and skilled teacher, reasonable mechanisms for assessing learning and practice, technical assistance, and a supportive environment for teachers' professional growth and development. All are necessary; no subset is sufficient.

Being trained and then not having access to hardware, the right hardware, or curriculum materials; having a computer in the classroom and not having the training to use it; trying a new instructional approach in isolation from other teachers, the principal, or the central office; buying computers with no plan for their use -- these are all complaints or cautions voiced by teachers. They are often a source of frustration and a reason for failure. While teachers, administrators, software/curriculum developers, or funders may elect to focus on one element of this system as a form of specialization or as a place to begin, it is important to recognize that any single element will be only a partial solution with limited scope and impact. Probably the most effective way to begin integrating technology into the curriculum is with a good answer to the question, "Technology, for what?"

As we support the development, implementation, or

dissemination of programs which integrate the computer into instruction, we must consider all the elements of the system and ensure that none is ignored.

Building on What is Known, What is Available and What is in Place

There is a substantial base of knowledge, material, and activity to build on in an effort to integrate the computer into instruction.

Education is high on the public agenda. Initiatives should capitalize on the interests and the existing initiatives of federal and state agencies, corporations, and foundations in school improvement, curriculum development, and teacher education. We should also take advantage of the self-interest of hardware manufacturers, publishers, teacher training institutions, and professional educational organizations. Formal and informal networks, collaborations, and partnerships are essential.

Over the last thirty years, there have been significant investments in school reform and improvement. As we look to integrate the computer into the curriculum, we should take advantage of what has been learned about introducing technology into education, about implementing and sustaining innovation in education, and about effective practice in areas such as teacher training and curriculum development. In considering the more general literature, we should be clear about the ways in which

computers are similar to previous efforts and innovations and how they are different.

We know that many teachers, schools, and districts across the country are actively working on integrating computers into the curriculum. There are some excellent pieces of software, large numbers of in-service and pre-service training programs and options available, and instances where technology has been integrated into the curriculum. New efforts should take advantage of what exists and is underway and seek to focus energy and investment on those elements of the system which are missing or neglected. From the teachers we interviewed, no single element stands out as the most pressing need.

Acknowledging and Supporting the Teacher as a Professional

While we commonly acknowledge that the teacher has ultimate responsibility for what happens in the classroom, we often define the role of the teacher as the final link in a one-way delivery mechanism to students, ignoring the teacher as a professional and key resource in the system. In contrast to this perspective, an essential factor in every success story about computer use that we heard was teacher interest, enthusiasm, and initiative. We also heard about the trials and tribulations of working with technology and curriculum and about the importance of informal, teacher to teacher problem-solving and support. If we want teachers to integrate the technology, to learn new skills, to take on difficult challenges, we need to treat teachers as

professionals, to listen to them, and to provide them with the time and the occasions to learn, to experiment, and to share.

As we move to integrate technology into the curriculum and to implement this vision, it is essential that we recognize the diversity of teacher experience, interests and concerns as well as the more obvious factors such as grade level and subject matter. To whet the appetites of teachers and schools, there must be legitimate opportunities to work with technology short of the full vision. There must be opportunities for teachers and schools to explore, to move at their own pace, and to experience the potential of curriculum-technology integration.

POLICY CONSIDERATIONS

In contrast to other institutions in the society, elementary and secondary schools have been slow to pick up and incorporate computer technology into instruction. Yesterday's state of the art is tomorrow's educational technology. For the majority of the field and the majority of teachers, integrated use of computers in the curriculum remains a practice at the cutting edge. To move this practice into the mainstream, teachers and schools need information and resources in the following areas:

1. Examples of what's possible.

   There should be a collection of examples of how to use computers as instructional tools. This collection should represent a range of approaches, along a number

of variables including grade level, subject matter, teaching/learning style, student population, computer functions (e.g., speech, color, graphics, speed, network), computer configurations (e.g., one computer per class for presentations, one computer learning station for small groups of students, a computer laboratory). The duration of these examples should fill the continuum from "five minute" ideas to year long courses.

Teachers need examples that are tangible and accessible -- that they can pick up and feel. There need to be examples that teachers can consider in light of their own objectives, educational values, and strategies. There need to be examples that teachers can discuss with one another. There need to be examples that can be examined and compared by groups of teachers and administrators so that local standards of review and evaluation can be established.

These will not be models for replication, but rather visions of possibilities that might inspire adaptations or related work. Visual images of teachers and students in action will be a necessary complement to written descriptions, software, and teaching materials.

2. Examples of support and training

Along with examples of curriculum - technology integration, we need examples of training, assistance, and support that facilitate that integration. We understand from teachers the various layers of support and training, but again, there is no readily available collection of examples. Experimentation and variation should be encouraged. There should be approaches to training for initial installation, ongoing support, coaching, and troubleshooting that are program-specific. There should be general opportunities for teacher professional growth and development. These approaches should respond to the needs of the reluctant novice as well as the seasoned educational "hacker." There should be examples of collegial support and networking, mechanisms for delivering support, assistance, and resources at the building and district levels. Principals, subject matter specialists and district level administrators need examples of how to structure and to deliver support for the integration and maintenance of technology in the curriculum. Variables in this context should include: subject matter, grade level, geographic setting, size

of district, technology or subject matter focus, and role of technology.

3. Information on results

In our survey, we found that teachers do not have difficulty assessing whether an administrative or managerial use of the computer meets their needs. After a short exposure or a brief training session, each teacher can decide for himself or herself whether an electronic gradebook or a word processor will increase productivity. Assessing instructional applications of computers, particularly those that are more open-ended in nature, is a more complex business. The question is not simply whether the old agenda can be accomplished more efficiently. We also need to consider whether the agenda has expanded, whether learning has broadened or deepened, and whether there are other benefits for teachers and students. If we neglect these questions, our efforts will be subjected solely to traditional "horse race" teaching experiments, perhaps dooming effective practices whose benefits do not fit the mold or the timing of standard impact measures.

We need to be able to provide teachers and administrators with much more information about the various

instructional uses of computers. Through observation and documentation, we can collect data on how the use of the computer affects content, curriculum, teaching methods, the roles of teachers and students, the relationships among teacher and students, and students and students.

There is also a need to develop effective techniques and instruments for assessing student learning. We need methods to define the kinds, pace, and depth of learning that various instructional uses of the technology promote and make possible.

Finally, we need to listen to teachers at all stages of computer integration, and gather their insights and their reactions to materials and training and support mechanisms.

All of these data together will inform teacher decision-making about the use of technology and will contribute to the development of more effective software, related curriculum, and teacher education and support.

TWO NOTES:

First, these considerations are cautious by design. There is no clear policy direction (although some might consider this a policy direction in itself). There is not enough experience or sufficient information to identify crisp models or exemplary

approaches. The goal should be to open up possibilities, not to shut them down. It is too soon to talk of mandates or tax incentives. The appropriate objectives at this time are: (1) to encourage creativity and experimentation, and (2) to require assessment and documentation.

Second, these considerations assume effective and far reaching channels for the flow of information and examples. Dissemination must be taken seriously and budgeted accordingly. We need to take advantage of networks and mechanisms of state and federal agencies (e.g., National Diffusion Network, NSF Chatauquas, OERI Regional Educational Laboratories and Research Centers), professional organizations, and educational media. We need to tap into the marketing capacities of hardware manufacturers and curriculum and software publishers. Finally, we need to create opportunities for teachers and schools to talk to one another.

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APPENDIX

TELEPHONE SURVEY

I. BACKGROUND INFORMATION

Name

M/F

Current Position

Elementary/Secondary

Subjects and Grades Taught

Size of School

Educational Background

Years of Teaching Experience

Do you have computers in your classroom?

Do you use a computer in your teaching or in your school-related activities?

How often do you use computers in the classroom?

How would you describe your classroom use of computers? Are you a non-user, an occasional user, a moderate user, or an extensive user

_____ non-user
_____ occasional user
_____ moderate user
_____ extensive user

II. COMPUTER USE

1. **(skip for non-users) How did you get started using computers?**

2. **What kinds of hardware and software does your school have?**

   How many computers?
   Where are they located?
   Is this a good place for them?

3. **(skip for non-users) How do you use computers in your class?**

   Type of use? As a demonstration devise with the whole class?
   As an activity center for individual students or pairs of students taking turns?
   In a computer lab?

   With all students?
   With high achievers?
   With remedial or poor students?
   With special needs students?
   With bilingual students?

   Purpose? For drill and practice or tutorials?
   For simulations and games?
   For exploration and problem solving?
   For games or simulations?
   For word processing or some other applications?
   For programming, computer literacy?

   Frequency? How often do you use computers?
   What portion of class time is spent using computers?

4. **Could you tell me why you don't use computers in your classes (or why you don't use them more extensively)?**

a. Is time a factor?

   In class, are there too many other demands on your time, too many things to do, material to cover? Outside class, do you have other priorities, too busy being involved in things that are more important to you?

b. Is it a matter of personal preference? (philosophical & pedagogical reasons)

Computers don't fit into how you want to teach?
Want to minimize the role of computers (and other technologies -- radio, TV/VCR, films)?

Could you explain how the computer affects the classroom, and why that's undesirable?

What other teaching tools or materials or aids do you prefer to use?

c. Is it a matter of facilities or software?

Has your school provided adequate facilities for computer use? Is the software adequate? Are there so many software choices that it's overwhelming?

Would better computer facilities or software alter your decision not to use computers?

d. Do you believe that computers are here to stay or are they a fad?

Do they remind you of other classroom innovations that have come and gone? What distinguishes a fad from a genuine innovation?

e. Is it a matter of training? (mention that we will cover this topic in more detail a little later)

Has your school or district provided any training? Have you had bad or frustrating experiences with training?

Is there some kind of training that is not now available to you that might tempt you to use computers or to use them more often?

f. Is the technology too complicated, intimidating? Does that make you reluctant to use computers?

Perhaps you've made an effort to use computers and found it too frustrating, overwhelming?

Has the fear of the technology influenced your decision not to use computers in your teaching?

Have you been put off by computer enthusiasts who talk over your head, make you feel stupid or foolish or inadequate?

If the technology could be dramatically simplified, would that in any way change your decision not to use computers?

g. Lack of Support (topic will be covered in more detail a little later)

Have you been alone in your efforts to introduce computers into the classroom? Has the school administration not provided moral or monetary support? Are there no other teachers who can help you?

5. **(skip for non-users) Why do you use computers in your teaching?**

   Could you begin with your own personal reasons?

   Student-related reasons? (To expose them to the latest technology? To help them learn better? As a student motivator?)

   To satisfy a school requirement?

6. **Do you use computers outside class?**

   For school-related work? (e.g., preparing class activities? for record keeping?)

   Do you use computers for tasks unrelated to your teaching (e.g., word processing)?

7. **Do other teachers in your school use computers?**

   Do you think your [use/non-use] of computers is similar to that of other teachers in your school? How typical or atypical are you?

III. TRAINING AND SUPPORT

Training

1. **Have you had training in the use of computers?**

   If not are you self-taught?

   If yes, could you give us some details about your training?

   Pre-service or in-service? Formal or informal?

   Who initiated the training?

   Why did you participate (mandatory, self-enrichment, tuition reimbursement)?

   Where did the training take place?

   Who paid?

   Was the training during school hours, after school, or during vacation?

   What was the training like? (topics, presentation)

   How long did the training last?

2. **Was your training adequate?**

   What were its strengths and weaknesses?
   What were the most important features of your training? (Instructor competence, hands-on access, follow-up?)

   In your opinion, was the training relevant to your teaching?

Support

3. **Is there any institutional support for computer use?**

   From computer coordinators in your school or district?
   From school administrators?
   From other teachers?
   From outside agencies (e.g. Boston Computer Society)?

   Has the school or district made any money available to buy equipment?
   to attend workshops or conferences?
   to take courses?
   to write software and/or curriculum materials?

   Have you received any help in scheduling computer use or in integrating computers into the curriculum?

Do you belong to a computer network?

Do you meet with other teachers to discuss computer use?

Are there rewards associated with knowing about and using computers in your school? (e.g. release time, compensation)

4. What support would you like that is not now available to you?

4a. (for non-users and occasional users) Is there some support that is not now available to you that might tempt you to use computers or use them more extensively?

5. Is funding for computers in your district too high, too low, or just about right?

Over the past 5 years, has the level of funding for computers gone up, down, or remained about the same?

IV. EFFECT OF COMPUTERS ON TEACHERS AND STUDENTS

1. **(skip for non-users) Has the presence of computers in your classroom changed your teaching in any way?**

   What difference has the computer made in your teaching?
   in your classroom behavior?
   in your teaching style?
   in your role as a teacher?
   in the content of what you teach?

2. **(skip for non-users) Has your use of computers changed over time?**

3. **(skip for non-users) Has your attitude towards computers changed as you've gained more experience?**

4. **In your opinion, is teaching easier or more difficult with a computer? (can be asked of both users and non-users)**

5. **Do you think computers have had an impact on students?**

   On how they learn?
   On how well they learn, on the quality of their work?
   On student motivation?
   On the relationship among students in the classroom?
   On the relationship between you and your students?
   On student behavior?

6. **Do you think computers have had an effect on the curriculum?**

   Have new courses been created?
   Have the goals and content of traditional courses changed?
   Have you had difficulties integrating software into your curriculum?

7. **Has your [use/limited use/non-use] of computers changed your relationship with other teachers?**

   Has the introduction of computers created divisions in your department or in your school (between "those who do" and "those who don't")?

8. **(skip for non-users) Has the introduction of computers into your classroom made teaching more exciting, challenging, frustrating, overwhelming?**

   Are you more or less likely to continue as a teacher because of computers?

9. **(skip for non-users) Has your use of computers led to new roles outside the classroom?**

   (e.g. computer coordinator, administrator, lecturer, teacher trainer, consultant, software developer?)

10. **Has the computers led to new roles for other teachers you know?**

    Do you know whether other teachers who use computers find their teaching more exciting, challenging, frustrating, overwhelming?

    Do you know whether they more or less likely to stay in teaching as a result of computers?

11. **Are computers or computer resources distributed equitably in your school or district?**

    Among schools in the district?
    Among programs in the school?

    In your school, do all students seem to have equal access to the computer, or do some students seem to use computers more than others?

    If there are differences in use, could you describe them?

    Are computers taking scarce resources away from other important areas? Can you describe these areas?

V. TEACHERS' INFLUENCE ON TECHNOLOGY

1. **How are decisions about computers made in your school or district?**

   As a teacher, are you satisfied with how decisions are made concerning how much money is spent on computers?

   - equipment purchases?
   - training?
   - how computers are used, and how they're integrated into the curriculum?

   Would you like to play a larger role in making decisions about how much money is spent on computers, and how they are used?

   Has your teachers' organization or union been involved in computer-related issues?

2. **Ideally, how do you think computers should be used?**

   Used by all students or only certain groups of students?

   Integrated into the entire curriculum or restricted to specific subjects?

   Used regularly or only as a supplement from time to time?

   Would you like to play a role in designing software for classroom use?

   If you were to design a software program for use in your classroom, what would it do?

3. **What's the most compelling reason for using computers in the classroom? For not using them?**

VI. MISCELLANEOUS

Is there anything else you'd like us to know?